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PROGRESS REPORT

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Chemistry?
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A SCIENCE SERVICE PUBLICATION

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Chemistry?

➤ WE ARE, from time to time, accused of including in this magazine material which is not strictly chemical in nature. What then is chemistry, and how may we distinguish between it and the other scientific disciplines?

A hundred years or so ago a fairly definite answer to this question might have been found. The various branches of science were distinct and separate. Chemistry dealt with the compositions and interactions of substances and physics with energy and the bulk properties of matter.

A more recent, and less serious, distinction between the physical sciences was that chemistry involves the performances of grossly inaccurate experiments with extremely pure substances, and physics the performance of extremely accurate experiments with grossly impure substances. Progress in instrumentation and processing over the last 30 years or more has, however, made this distinction invalid, except at the high school level.

The truth is that all the sciences have expanded to such an extent in recent times that they all now overlap one another, and it is difficult to think of a problem which does not fit into more than one field.

Even the line between physical and natural sciences has become blurred — how would you classify the current investigation of the structure of DNA? — and chemistry and physics have become, like the Democrats and Republicans, distinguishable only at the extremes.

It should now be clear that, since the object of CHEMISTRY is to correlate chemistry as it is used with chemistry as it is taught, we would be defeating our own purpose if we limited the contents to what might be called 'classical chemistry.'

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A CBAC Progress Report

A new introductory chemistry course was described in the February issue of CHEMISTRY this year. Its main feature is the attempt to organize a course around the concept of the chemical bond. This experiment in curriculum development is being financed by grants from the National Science Foundation to Earlham College in Richmond, Indiana. The present article reports the results of last year's trial with 600 students in nine high schools across the country, the summer institutes for high school teachers, the revision of the textual material based upon last year's experience, and the plans for further development.

➤ By the end of the last academic year eighteen chapters of text comprising 462 pages of typescript had been reproduced in four volumes by the photographic offset process. This was accompanied by a student laboratory manual containing 20 experiments and a comprehensive teachers' manual for the laboratory. Due to limitations of time and late arrival of the final chapters only the first 13 chapters were covered in the trial schools, but all 20 laboratory experiments were tested. A collection of reprints from the Journal of Chemical Education has also been published for supplementary reading.

As an aid in assessing the usefulness of the course in the classroom, Dr. F. L. Ferris, Jr. of Educational Testing Service worked with the Chemical Bonds Approach Commit-

tee (CBAC) in developing an examination program. The examinations were designed to reveal the student's ability to reason within the unique framework of the course. Preliminary analysis of the examinations indicates that the results are statistically reliable and that the students seem to be able to master a good share of the subject matter. The performance of the bulk of the students on the SCAT aptitude examination was above the 75th percentile of the national norms for high school students. The correlation of the SCAT scores with the student's achievement on the first CBA examination was low and the correlation decreased as subsequent chemistry examinations were given. This decrease in correlation with the SCAT test parallels the experience with the PSSC physics course.[1] These low correlations with aptitude tests apparently are real as the tests exhibit satisfactory statistical reliability. The reasons for this low correlation are receiving further study.

In four institutes sponsored by the National Science Foundation some 130 high school and teachers college faculty members studied the CBA text materials and carried out the laboratory experiments. These institutes were held at Brown University at Providence, R. I., Kenyon College at Gambier, Ohio, Reed College at Portland, Oregon, and the University of Florida at Gainesville.

Lectures were given on background material beyond the level of the textbook presentation. New ideas on the charge cloud model of the atom as well as current ideas on the orbital model were emphasized. In the short period of six weeks (one Institute of 7 weeks) available in the Institute stress had to be placed on the major concerns of the course such as free energy, organization energy, heat of reaction, and their interrelations rather than on descriptive chemistry of the elements and chemistry with which the teachers were judged to be familiar.

Another phase of chemistry unfamiliar to many of the Institute participants was the content of Volume IV, the chemistry of one functional group, the OH group, as it occurs in different environments, e.g., in Na-OH, $Si(OH)_4$, $O_2S(OH)_2$, C_2H_5-OH, and CH_3COOH.

Daily discussions of textual material were held with instructors who for the most part were involved in the writing group at Reed College in 1959 and who had taught the course during 1959-60.

The laboratory work as described in the previous CHEMISTRY paper (vide supra) was of sufficiently different character from the experiments usually performed in high school courses for the teachers to carry out a number of the experiments to acquaint them with pitfalls their students might encounter. Many modifications and extensions of experiments for future revision were discovered during the Institutes.

Molecular models for use in the high schools for the coming year were constructed during the Institutes. These were based in large part on models proposed by Prof. R. T. Sanderson.

Visiting lecturers previously connected with the CBA project, H. A. Neidig, Frank Verhoek, L. E. Strong, Frederick Ferris, Seymour Zenchel-

[1] F. L. Ferris, Jr. *The Science Teacher* 26, No. 8 Dec. 1959.

sky and G. E. Kimball gave special lectures at the Institutes.

Special tests prepared by Educational Testing Service were given at the beginning and end of the Institutes to assay progress. These were also used to acquaint the teachers with the type of questions considered of value for presenting the course to students.

During the course of the trial year the CBA Committee became increasingly aware of the pedagogical advantages possessed by the "charge-cloud" model of atomic structure recently revived by Dr. George E. Kimball [2, 3]. This approach to atomic and molecular structure assumes that the electrons may be represented as spherical charge clouds of negative electricity and that their attraction for positive nuclei and their repulsion for each other is governed by Coulomb's law. This simplified approach has the great virtue that the correct molecular geometry of many simple compounds is obtained without the need for hybridization of atomic orbitals. The conventional orbital picture is not abandoned, but is postponed until some feeling for molecular geometry and its effect on physical and chemical properties has been established by a consideration of the consequences of the charge-cloud model. Considerable attention is given to "mental model" building in science and the fact that these models should be judged by their usefulness in correlating natural phenomena. Thus, the charge-cloud and orbital models are used interchangeably throughout the rest of the text, the choice of the more appropriate model being dependent upon which one yields the more useful result in the more direct manner. At the present time the first eight chapters of the extensively revised text have been printed and revision of the rest of the text is continuing. The nature of the course after revision may be discerned from excerpts from the actual text.

[2] G. E. Kimball and E. M. Loebl, J. Chem. Ed. *36*, 233 (1959).

[3] Private communication.

How Do We Get the Facts?

"If the problem of why properties change is to be solved by using ideas about chemical bonds and structure, we must first devise methods of finding out what is inside molecules. Now molecules are very tiny things and we can't get at them and look directly to see what atoms are there. So we have to find other ways of studying them. The methods we use are very much like the methods you will use in the laboratory in determining the contents of a closed box. After receiving a taped box containing an unknown object, you will be asked to note observations obtained by handling the box. Each of these observations will provide some information as to the characteristics of the object. By combining these ideas, you can construct a mental picture of the object in the box. Although you are not able to see or to touch the object, you can describe it on the basis of the inferences made from your observations.

"Similarly, we cannot see or touch an individual molecule. From observation, we can obtain information concerning the molecule which can be used to construct a mental picture or a scientific model of the molecule.

"In subsequent chapters of this book we shall see how a chemist con-

structs scientific models of molecules and atoms, and what the results of some of these operations are. In some cases, we shall see how the results are turned into answers to the questions chemists ask about the nature of substances.

Related Problems in Chemistry

"While it has been stated that the central concern of the chemist is to understand chemical change, it is necessary to point out that there are several other important problems within this main one. For example:

(1) Why is it that some changes occur and others do not?

(2) Why do some changes occur so quickly that they are explosions while others take years?

(3) How do temperature and pressure affect chemical changes?

"As we consider these questions throughout this book, we shall find out that scientists have developed the concept of energy to help answer them. When chemical changes occur they are always accompanied by transfers of energy. For example, the changes that occur in photosynthesis of food in growing plants and the metabolism of this food in animals are both accompanied by energy changes. When the carbon dioxide and water are rearranged into complex new patterns in substances called carbohydrates energy in the form of sunlight is absorbed to effect this chemical change, called photosynthesis. When the complex carbohydrate molecules are eaten by an animal, the decomposition to simpler molecules is accompanied by release of energy. In this process, called metabolism, the energy appears partly in the form of heat to keep the animal warm, partly in the form of work to enable the animal to move, and partly in the form of chemical energy to aid the construction of various parts of the animal's body.

"In the past, some plants have been changed into coal with transfer of energy. As coal is burned, a transfer of energy takes place and the surroundings are heated.

"In all chemical reactions the exchange of energy can be measured (usually as heat) and expressed in quantitative terms. We shall see that in some chemical reactions the exchange of energy is small; in others it is large. There is a relationship between the magnitude of the energy transfer and the ease with which a chemical change takes place.

Explanations

"In this chapter on several occasions the term "explain" has been used. When a chemist seeks to explain a property of a substance, he seeks to connect that property with other properties of the same substance and of other substances. As an example, a chemist wonders why a diamond is hard when graphite is soft, or he wonders why table salt dissolves in water while diamonds do not. Or he wonders if there is any connection between the fact that table salt melts at 800°C and dissolves in water, while gasoline freezes at about —150°C and does not dissolve in water. In Chapter VI we will consider ways of explaining these, and we will find, indeed, that they are related.

"The explanation of the facts found by experiment is thus the demonstration of interconnections among the facts. It is a curious feature of human experience that when we are confront-

ed with two or more facts, we cannot ordinarily see any connection between them by simply looking at them; however closely we may observe, they remain just isolated facts. To achieve interconnections among seemingly isolated facts, the chemist makes use of imaginative ideas, called theories or concepts.

For many facts in chemistry we have found interconnections and, hence, explanations. There are still other facts whose connections remain to be established. Chemistry is somewhat like a piece of cloth. Some threads are interconnected and form a pattern while other threads run off into loose ends. We will discuss both kinds of threads in this course. You may see how to weave some of the loose threads into the cloth."

CHEMICAL REACTIONS

"We have already raised the question, "How do we get the facts about substances and about chemical reactions?" We said that in the laboratory a chemist makes observations and that the process he uses can be compared to the process you used in determining the contents of a sealed box. Let us review briefly how a chemist progresses toward a greater knowledge of his science. Starting with a question raised by observations, he then performs an experiment, carefully recording his observations in his laboratory notebook. Thinking about these observations and relating them to his concepts of the nature of atoms and molecules and the ways they are bonded in compounds, he tries to devise an explanation of the observations made in the experiment. To test how useful his explanation (sometimes called an hypothesis) is, he works out a new experiment, tries it and makes more observations.

"Now the observations the chemist makes are really the answers to questions he asks about what goes on during an experiment. He knows that if his hypothesis is a good one, then with it he will be able to predict that such-and-such results will be observed, and that if contrary results will be found, then the hypothesis is worthless. He will not, of course, ask the same questions in all experiments. His selection of the questions to be asked will depend on the nature of the hypothesis to be tested and on his past observations about what facts are related to his hypothesis. He may know, for example, that if his hypothesis is a good one, ammonia will be formed in a given situation. To decide whether ammonia has in fact been formed, he will look carefully for its known characteristics; in this case odor alone might be enough. Let us list a few questions which might be raised in other cases.

"Are the starting materials and the products gases, liquids or solids?

"What is their color? Their density? Their hardness or softness, brittleness or strength?

"Are they soluble in water — in benzene — in alcohol?

"At what temperature do each of the starting substances and the products melt? and boil?

"Does the reaction mixture get warmer or cooler as the reaction proceeds? Is light produced? Is it noisy?

"Are there special conditions of heat or pressure that are necessary to make the reaction go?

"How long does it take for the reaction to take place?

"What is the chemical composition of each of the substances, both starting materials and products?

"The number of possible questions is unlimited, but in any given experiment only a limited number of questions will relate directly to the problem.

"Note that some of the questions are best put in the form, "*What* happens?" while others can be put in the form, "*How much*?" Answers to the first type of question are *qualitative;* those to the second type are *quantitative*. We can, of course, get both qualitative and quantitative answers to the same question depending on how we carry out the experiment. For example, we can take a few crystals of sodium chloride and put them in water and see that they dissolve. Qualitatively, then, we can say that sodium chloride is soluble in water. However, we can also weigh the amount of sodium chloride that will dissolve in a measured volume of water and find that the most that we can dissolve in water at 25°C is 36 g. per 100 ml. This is a quantitative answer or observation.

"*Exercise:* Is the determination of the melting point and the boiling point of a substance a qualitative or a quantitative measurement?

"In the following paragraphs we will examine a few of the amazing transformations that substances undergo in various circumstances, in order to raise the kind of question suggested at the beginning of this chapter. We will not attempt at this point to suggest how these transformations can be understood; that will come later. We will, however, try to raise some of the questions for which you may be able to find answers in the laboratory. The reactions will have some significance in that they involve substances and ideas with which chemists are presently concerned. We hope they will raise questions in your mind for which it will seem to be important to seek answers."

STRUCTURES FROM ELECTRONS AND PROTONS

"Our search for some properties common to all substances has led to electrons and protons. Experimental evidence indicates that each substance has its own characteristic number of electrons and protons. Unfortunately no simple relationships developed between numbers of electrons and protons and observed properties. Something more needs to be included in our thinking if we are going to succeed even modestly in the attempt to connect the diverse properties possessed by different materials.

"In considering the differences between diamonds and graphite, we were led to conclude that these two substances must differ in structure since they do not differ in composition. We now plan to pursue the kinds of structures that should develop when electrons and protons are assembled. We will begin by assuming that the nuclear atom model proposed by Rutherford is the best starting point. The chemist is primarily concerned with the arrangement of electrons around the nucleus of this type of atom.

"Electronic arrangements will prove extremely helpful in relating the properties of substances. They will not, however, provide a complete answer to the problem. A second feature of significance in determining the prop-

erties of substances is what we call the disruptive process. This process is largely controlled by the temperature and will be discussed later. This discussion will lead to the conclusion that a particular substance has a set of properties which are largely the result of its structure on the one hand, and its tendency to come apart on the other. In other words, substances have features of organization and disorganization within them, and the particular properties observed are determined in large measure by the balance between these features.

"A third feature is concerned with the masses of substances. This will also be taken up later. The mass of a substance is determined by the masses of the various nuclei. Methods of determining these masses will be considered.

"How can we use the first feature — the presence of electrons and protons — to build pictures of atoms? Our answer will depend in part on what we mean by "building a picture."

Mental Models

"In the remainder of this chapter we will be concerned with a special type of picture building, the scientific strategy of model construction. This is a process in which a scientist builds a picture in his mind that provides a way of thinking about his experiments. Sometimes this mental picture can be converted into a physical model, an actual object. More often, the mental picture remains just that — mental.

"Such models are used to simplify and facilitate our thinking. If they are useful, they lead to conclusions which correspond to what we actually find in the laboratory. Not infrequently scientists think of a mental model which for several cases is useful, but which finally turns out to be misleading and so is discarded. For example, astronomers for thousands of years were able to make use of an earth-centered model of the universe. Many problems could be solved by an intelligent use of this model, but it finally had to be discarded as man's factual knowledge of the heavens expanded. Most commonly a mental model is partially useful and partially misleading. When a model is misleading, one tries, then, to modify it. We always remember, however, that the model is never more than a useful device; it must not be confused with the reality that it mirrors.

"Whenever we build mental models we start with a set of assumptions. In your study of geometry you may have called them postulates. Though some of our assumptions may appear to you as little more than guesswork, useful assumptions are those which in a sense are forced upon us by the nature of our experience. At first, they are often little more than intelligent guesses — what we often call hypotheses. The scientist asks, "What would follow if we assumed that such-and-such is true?" Some of these hypotheses prove immediately and dramatically fruitful, and some become indispensable principles underlying all further investigation.

Pauli Exclusion Principle

"A major example of an assumption that will be indispensable to our model building is the "Pauli Exclusion Principle." For many years, chemists found it difficult to construct models of atoms that would give any clue as

to why different substances have different physical and chemical properties. Although they had developed a variety of relationships and trends among the various properties of the chemical elements, they could not easily relate these properties to the properties of fundamental particles. Finally in 1925, Wolfgang Pauli developed the notion, now treated as a reliable principle, that with sufficient attractive force present, two, but no more than two, electrons can occupy the same region in space. Using this assumption, chemists found that interrelationships between ideas of structure and observed properties were clarified. We cannot discuss here the many forms of testing to which this assumption has been subjected. But one of the most important tests is the repeated successful use of it which we will make as we go along. We will find it a most effective aid to our thinking; it yields results that are valuable to us in further investigation.

"Starting with assumptions such as Pauli's, reasoning leads us to certain conclusions. In chemistry, sound conclusions correspond to the observed properties or behavior of some substance. Thus, a useful mental model of hydrogen should lead us along a line of thought with which we could calculate the melting point, the boiling point, the density, the chemical reactivity, and all of the other properties of hydrogen. No mental model yet devised will do all of this in detail, but the best ones are extremely useful.

"Our mental model is to be constructed from both electrons and protons. Later we will find it necessary in addition to introduce neutrons.

Assumptions About the Electrons in Atoms

"In our model building, we shall work in accordance with the following assumptions about the properties of electrons:

"a. Electrons in an atom may be represented as negative electric charge clouds.

"b. Electron clouds repel each other with a force described by Coulomb's law.

"c. An electron charge cloud tends to expand in size.

"d. Electrons are attracted by protons with a force described by Coulomb's law.

"e. With sufficient attractive force present, two, but no more than two, electrons can occupy the same region in space. (Pauli Exclusion Principle)

Assumptions About the Protons in Atoms

"Our assumptions about the properties of protons will be the following:

"a. Protons are electric charges, for our immediate purpose are considered as dimensionless — that is, they can be thought of as points.

"b. Protons repel each other with a force described by Coulomb's law.

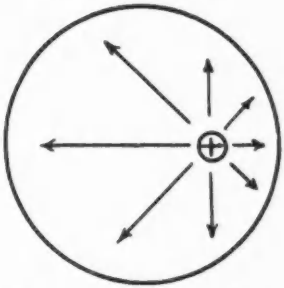
"c. Protons attract electrons.

A Model for Hydrogen

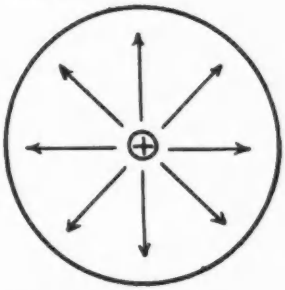
"Hydrogen is the simplest of all elements. By experimental techniques it has been determined that each atom of hydrogen is made up of just one proton and one electron. What sort of model can we construct from these two particles using the above assumptions?

"If we imagine a single electron

and a single proton near each other, an attractive force will be present which will cause the two to draw together. Even when the proton penetrates inside the electron charge cloud, an attractive force will persist, although it now operates in all directions around the proton. So long as these forces are unbalanced the proton will continue to move.



"At some point within the charge cloud, the forces in various directions will all be just right to balance each other. In such a three-dimensional, electrical tug-of-war the proton can finally remain stationary within the electron cloud. Let us suppose, for simplicity, that the electron becomes spherical in shape.



The Nucleus of the Atom

"Our assumptions have led us to a model of the hydrogen atom in which one proton is in the center of and surrounded by one electron. Fig. 1 is a photograph of an attempt to mimic the mental model in plastic. In the figure, the clear plastic sphere represents the charge cloud while the dark spot in the center represents the nucleus.

Such a model shows only the geometrical relations but nonetheless is quite useful in aiding our minds to grasp the three-dimensional character of the model. These and similar models will be particularly useful in more complex systems.

"This model is consistent with the picture Rutherford developed for the metal atoms in the foils which he bombarded with alpha particles. The hydrogen atom is simple, containing only one proton and one electron. Metal atoms are complex, containing many protons and many electrons. It appears that, from the simple to the complex, all atoms are constructed in the same way with protons at the center surrounded by electrons. The central core of protons is called the nucleus of the atom. You may note some similarity between this use of the term nucleus and its use in the description of a biological cell.

"This general picture is useful as a model for all atoms. We assume that other atoms each have a single nucleus, but with more than one proton in each nucleus. The nucleus of a neutral atom is always surrounded by electrons.

Because of the Pauli Exclusion Principle, however, it will not be expected that the electrons can always form a single spherical cloud. We will discuss other arrangements in another chapter.



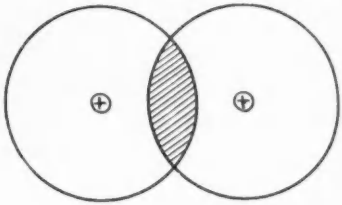
FIG. 1
Hydrogen Atom Model

Hydrogen Molecules

"Imagine two hydrogen atoms near, but not touching each other. The two electrons repel each other and the two protons repel each other. Each proton attracts not only its nearer electron, but also the electron in the other atom. When the various attractions and repulsions are combined, their sum is zero. This means that the separate atoms do not further affect each other. If the distance between the atoms varies, the net force still remains zero — with one exception, a highly important one.



"Suppose the two atoms are pushed together so that the electron clouds overlap slightly. The shaded area represents this overlap. Now, as before, the protons repel each other and each proton attracts electrons. Notice that the repulsion between the two electrons, however, is altered. Those parts of the electron clouds which do not overlap repel each other as before, so as to push the atoms apart. Those parts which do overlap can repel in the opposite direction so as to push the atoms together. As a con-



sequence the net repulsive force between the electrons must be smaller than it was before overlap occurred. Hence, the two atoms will move together until the electrons completely overlap and the protons take up positions consistent with their mutual repulsion. Fig. 2 illustrates the result, consisting of two hydrogen atoms held together by electrostatic forces.

"A third hydrogen atom cannot now merge with the first two. This is forbidden to our model by the Pauli Exclusion Principle. We can antici-

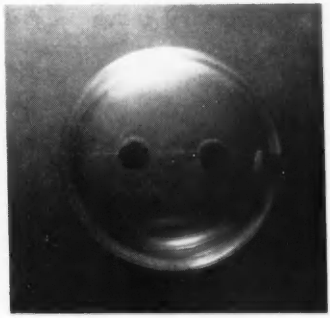


FIG. 2
Hydrogen Molecule

pate then, that any number of hydrogen atoms will all sooner or later be found together in pairs. Each pair will be essentially inert, in relation to the others.

"Each pair of hydrogen atoms is stable and is referred to as a hydrogen molecule. The use of symbols as previously developed will then lead us to H_2 as the symbol for hydrogen. Later we shall see experimental evidence that, in accord with our predictions, the molecule of hydrogen is indeed diatomic.

Covalent Bonds

"The joining of two atoms by electrical attraction produced through the overlap of two electron clouds will occur in other elements. This attraction produces a rather powerful link between atoms. Chemists refer to this link as "the covalent bond." It is a bond in which two atoms cooperate with each other to produce an attractive force. It is sometimes referred to as the bond by which two atoms are joined through a shared pair of electrons. Some of its special characteristics will be explored later."

All the evidence accumulated over the past trial year indicates that the students are capable of grasping the material in the course and that they have considerable enthusiasm for the presentation and subject matter. At the same time, it is clear that further experimentation with the course is necessary before a final version can be achieved. During the academic year 1960-61, under a further grant from the National Science Foundation, the second version of the course will be tried out in about 80 schools and will involve some 6000 chemistry students. These schools are distributed among 24 states. In addition to these official trial schools the course materials will be used informally by another dozen high schools and colleges.

It is expected that interest in this approach to introductory chemistry will continue and plans are being formulated to hold an expanded number of summer institutes next year.

During the past year the personnel associated with this project have made numerous speaking appearances at the request of interested groups and Laurence E. Strong and Paul Westmeyer attended the Seminar on the Teaching of Chemistry, sponsored by the Organization for European Economic Co-operation (OEEC), at Greystones, Republic of Ireland. Recently Laurence E. Strong has accepted an invitation from the United States-South Africa Leader Exchange Program to visit secondary schools in the Union of South Africa and discuss recent developments in science education.

The original as well as the revised version of the course was prepared under the direction of Laurence E. Strong, Earlham College, Richmond, Indiana, as Editor-in-Chief, with assistance of the following contributors:

Arthur E. Bereit, Central High School, Phoenix, Arizona.

Kenneth Borst, Leonia High School, Leonia, New Jersey.

Leallyn Clapp, Brown University, Providence, R. I.

James DeRose, Newtown - Marple High School, Newtown, Pa.

Robert Fitzgerel, R. B. Worthy High School, Saltville, Va.

Edward Fuller, Beloit College, Beloit, Wisconsin.

Eric Graham, Kenyon College, Gambier, Ohio.

Arthur Livermore, Reed College, Portland, Oregon.

Richard Miller, Los Angeles High School, Los Angeles, California.

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Henrietta Parker, Shortridge High School, Indianapolis, Ind.

Robert Shewbert, Grant High School, Portland, Oregon.

Wendell H. Taylor, Lawrenceville School, Lawrenceville, N. J.

Frank Verhoek, Ohio State University, Columbus, Ohio.

Paul Westmeyer, University of Illinois High School, Urbana, Ill.

Harold Wik, Sunset High School, Beaverton, Oregon.

M. Kent Wilson, Tufts University, Medford, Mass.

This group has received invaluable assistance in the project from a large number of interested persons. Outstanding among these has been George E. Kimball of the A. D. Little Co., Cambridge, Mass., who has given freely of his time to explain his charge-cloud approach to atomic and molecular structure. Wayne Booth of Earlham College has advised on rhetorical style. A. B. Garrett, Ohio State University, Columbus, Ohio, and R. B. Marschner, Standard Oil Co. of Indiana, have rendered valuable editorial assistance.

The main office of the project is at Earlham College, Richmond, Indiana. Further information can be obtained there, and sample copies of some materials are available at cost.

New Grant Program Started

➤ An experimental program of general grants designed to strengthen the scientific capability of the nation's colleges and universities has been announced by Dr. Alan T. Waterman, director of the National Science Foundation.

The grants will be given to the educational institutions without restriction for use and will complement Foundation support for specific science and science education projects.

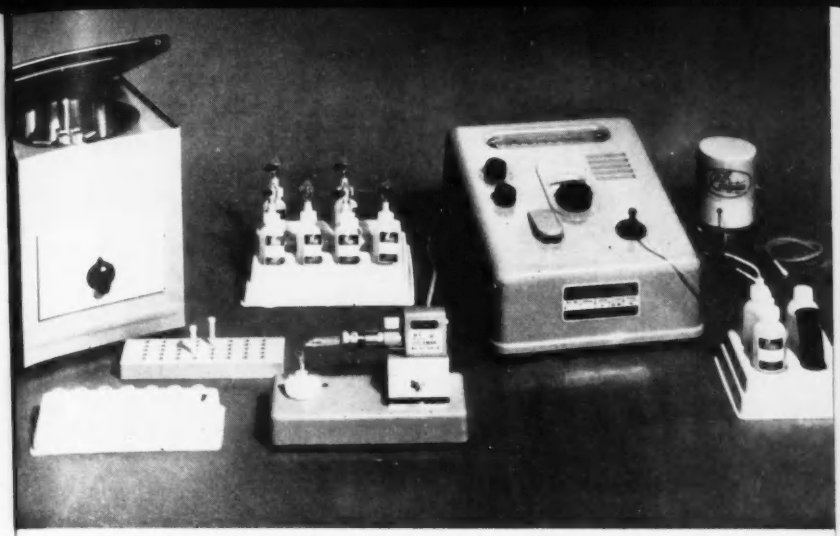
"Federal support of research for particular projects, by earmarking funds for those projects, tends to handicap the institution in developing its overall scientific capability," Dr. Waterman said.

The new program of institutional grants will enable the college or university to get necessary equipment, employ a needed instructor, technical assistant or specialist, acquire the data that "may make a great difference in the prompt solution of some difficult situation," Dr. Waterman explained.

Amount of grants to an institution will not exceed $50,000 for any one fiscal year.

Generally they will be limited to five percent of the Foundation's research grant made to the institution in the previous year.

Although the institutions will be free to allocate the funds without restrictions, they will be required to report to the Foundation annually on how the funds have been expended and the purpose underlying the investment.



Apparatus Article

Ultramicro Analysis

➤ ANALYSIS of samples, 20 microliters or less in size, is routine with the new Coleman Ultramicro Analytical Program. Originally designed for clinical analysis, the Coleman system permits accurate analysis of minute samples on the widely used Coleman Junior Spectrophotometer. The system is precise, dependable and unusually economical.

Key to the program is a special self-emptying ultramicro cuvette, which requires only 100 microliters of sample solution but provides a full 1.00 cm light path for the spectrophotometer beam.

The cuvette carrier orients the optical faces of the cuvette with respect to the spectrophotometer. The carrier slips out of the spectrophotometer well in seconds, instantly adapting the instrument to analysis with other size samples.

Other elements included in the program are a specialized micro-centrifuge, a precision ultramicro titrator, and 12 analytical procedures. A set of 12 clinical procedures is also available, complete with its own set of reagents and volumetric dispensing equipment.

Because the Coleman Ultramicro Analytical Program integrates perfectly with an instrument routinely used in thousands of laboratories, adoption of the Coleman ultramicro techniques does not require purchase of special instrumentation which will lie idle when macro determinations are being made.

For additional information, contact D. L. Hackler, Coleman Instruments, Inc., 42 Madison Street, Maywood, Illinois.

Du Pont

This is the first of a series of eight articles to be presented in CHEMISTRY this year. Many of the students now preparing for a career in chemistry will eventually join one or other of the large corporations and this series, featuring eight of the major companies employing chemists in the United States, is intended as a preview into the type work that they will be doing.

➤ More than a century and a half ago Du Pont was a small company of six owners and a dozen employees making high-quality rifle and blasting powder for a pioneer country. Du Pont, today, is an institution of more than 220,000 stockholders and 87,000 employees producing vital products for a rich America.

Du Pont has come to occupy a unique place in the nation's industry. Though Du Pont is large, more than a dozen U. S. corporations are larger. Though Du Pont is the largest overall producer in the chemical industry, eight of its principal competitors are larger in the fields in which they compete. Yet, Du Pont's diversity of activities and its research achievements have succeeded in making its name a by-word for American chemical developments.

From a single item of black powder has grown a family of more than 1,200 products and product lines. At the beginning the founder carried out experiments in his own kitchen. Now there are 31 research and development laboratories, employing 2,300 technically trained workers. In addition, more than 2,000 scientists are busily engaged in 70 other laboratories, checking the quality of Du Pont products and helping customers make new and better products from the Du Pont materials they buy.

From the tiny mills along Brandywine Creek near Wilmington have grown 78 plants scattered from coast to coast. The technical span reaches from water-driven grinding wheels to intricate, complex tools which make the operating investment per chemical worker the second most expensive in U. S. industry.

Du Pont's role in national defense has grown from supplying powder for American warships fighting Barbary pirates off Algiers in 1805, to the design, construction and operation of huge plants for the production of nuclear materials, which, incidentally, are being turned increasingly to peaceful uses.

The story goes on. A few customers, most of them within a wagon trip of Wilmington, have become some 75,000 large and small, across the continent. A handful of suppliers has increased to an estimated 30,000, ninety per cent ranked among small business.



➤ THE BUILDINGS *spread out on the north bank of the Brandywine River, near Wilmington, Del., comprise Du Pont's Experimental Station, one of the largest industrial research laboratories in the world. Newest buildings are in the upper half of this aerial photograph. Research conducted at the Station has led to the development of numerous new and improved products, including nylon and neoprene. Today about half of Du Pont sales are from products stemming from Du Pont research, and introduced within the past 25 years.*

Du Pont's strength today lies in diversity. Here is an example. In the first World War, Du Pont supplied 40 per cent of all military explosives used by the Allied powers. This output represented 85 per cent of Du Pont's total production.

In contrast, production of military explosives in World War II accounted for less than 25 per cent of the company's total production, although, in volume, it was several times that of the previous war. This sharp reduction in the relative importance of military production reflects the widely diversified character of Du Pont operations.

About half the company's sales in recent years, for example, represent products introduced commercially by Du Pont within the past 25 years, a factor reflecting the scope and effectiveness of the company's program of fundamental research, initiated in 1927.

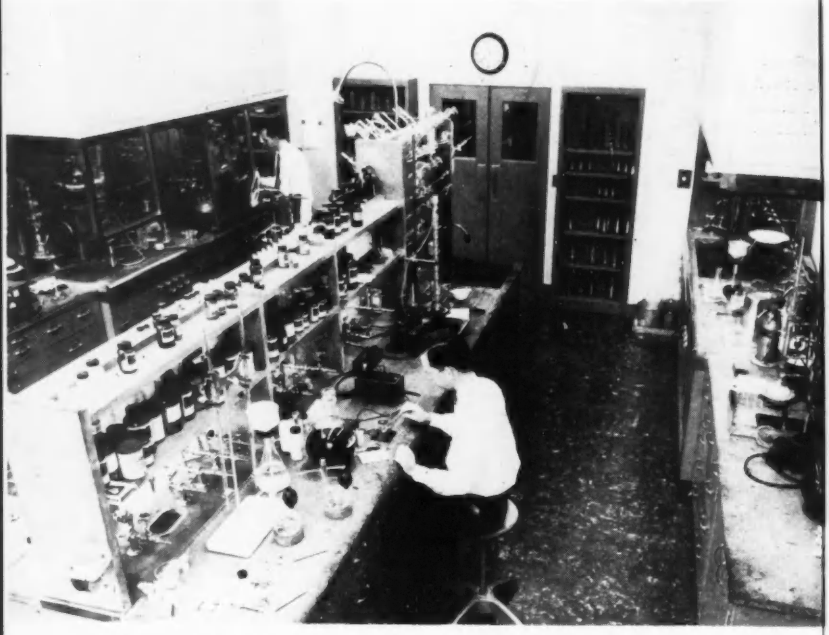
This type of research was started to uncover new scientific knowledge without regard to specific commercial objectives. The development of nylon, the world's first truly synthetic fiber, stemmed from basic studies carried out under the fundamental research program. Other studies in this program also uncovered knowledge

which laid the foundation for the commercial development of polychloroprene rubber, better known as neoprene, the first successful general purpose synthetic rubber.

Among the latest results of Du Pont's research program are "Delrin" acetal resin which shows promise of doing, finally, what some earlier plastics had been expected to do — replace metal for many engineering applications; "Mylar" polyester film, the strongest of all plastic films, which was recently viewed by millions all over the world in its travels through space as the first "Echo" satellite balloon; "Dycril" photopolymer printing plate, a photosensitive polymer that offers a convenient, quickly-processed material to replace traditional metal plates for many applications in the graphic arts and printing industries; and "Lycra" spandex fiber — elastic, strong, and light in weight.

Introduced in the early 1950's, "Dacron" polyester fiber and "Orlon" acrylic fiber are already well known to the American public.

The chemical industry rates among the top in appropriations for research budgets. In 1959, Du Pont alone spent $90 million on research and de-



➤ THE TWO-MAN LABORATORY *is the basic research facility in the new buildings of the Du Pont Company's Experimental Station near Wilmington.*

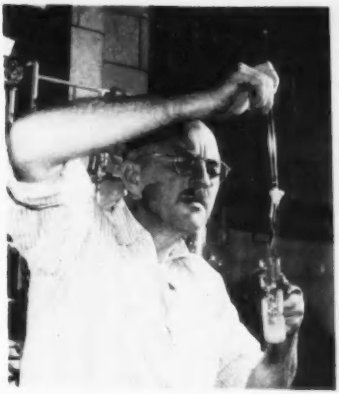
velopment, of which nearly $15 million went for basic research. A major part of its research budget — and this is typical of the entire industry — is devoted to improvement of existing products.

What does all this mean to the average American citizen? It means, for example, that because of the high proportion of operating income spent for product improvement and discovery in the chemical industry, his paint job is lasting two or three years longer than it would have 20 years ago; that his tires are giving him 15,000 more miles than they would have 25 years ago; that he has a wide choice of wrinkle- and crush-resistant summer suitings instead of a couple of fabrics virtually unimproved in 75 years.

It means that his wife's wardrobe is now less costly (even in this inflationary period) and infinitely more attractive and varied than it could have been 35 years ago; that his garden or his farm is yielding more and better products thanks to the remarkable improvements in agricultural chemicals during the past 30 years; that his food stays fresh longer because of improved refrigerants and packaging films.

Research is nearly all risk. As Crawford H. Greenewalt, Du Pont's president, puts it: "I would say that not more than one in twenty of our research investigations ever rings the cash register, and that in money not more than one out of five research dollars ever pays off."

Among the historic risks Du Pont has undertaken are the production of synthetic organic dyes — 18 years and $43 million invested before the



PROBABLY *the most dramatic moment in Du Pont research history is re-enacted above — the birth of the first completely synthetic fiber, impractical for commercial use but true forerunner of nylon itself. Here chemist Julian Hill shows how he pulled molten sample of material from a laboratory tube at the company's Experimental Station near Wilmington, Del. The molasses-like mass stuck to the glass stirring rod and was drawn out into a thin fiber.*

venture actually turned a profit; nylon — 13 years and $27 million; "Orlon" — eight years and $25 million; synthetic ammonia — 10 years and $27 million; "Delrin" — 11 years and $42 million.

While Du Pont is not disposed to forecast the future on a crystal-ball basis, it is possible, nevertheless, to sight along certain lines of research that already are laid down. Among them are: a massive exploration of synthetic fibers; the development of new plastics for engineering applications; "pure" studies in physics and

biology — relatively new areas of Du Pont research; studies of high-temperature metals, like titanium and niobium, expected to be used widely in space-age equipment; the development of synthetic rubbers that can withstand extremely high and low temperatures and the impact of atomic radiation; paints that need no solvents; agricultural chemicals that control the growth of plants and increase a crop's resistance to frost and heat; new plant and animal nutrients; and many others.

To the young scientist or engineer, the chemical industry offers exceptionally attractive opportunities. The diversity of its products has made it a major employer and a basic supplier of every manufacturing industry. Moreover, the chemical industry is traditionally among the leaders in employee benefits and working conditions.

Du Pont's employee benefits program is among the foremost in American industry. From Eleuthere Irenee du Pont's intimate and neighborly concern for his workers has come an awareness of responsibility toward safety and the well-being generally of employees that has long been in the forefront of the nation's industrial relations programs.

New Membrane Filters Sea Water

➤ A MEMBRANE to filter the salt out of sea water has been announced at the University of California, Los Angeles. It is said to be 100 times more effective than previous commercial membranes.

This new and promising filter was developed by research engineers Sidney Loeb and Srinivasa Sourirajan. The membrane, or film, has a large number of tiny pores which in effect filter the salt water and separate the brine from the potable water.

To make their film, the UCLA engineers mix cellulose acetate with aqueous magnesium perchlorate solution and acetone, and then cast the sticky mixture cold on a glass plate.

After putting the glass plate into cold water, a film four thousandths of an inch thick is stripped from the plate and then shrunk slightly in hot water. The finished membrane, which can filter water 100 times faster than previous commercial films, is mounted on each side of a porous steel disk.

Any number of disks are then stacked in a frame press, salt water is circulated through the unit at 1,500 pounds per square inch presure, and the desalted water flows out from the bottom of the unit.

With their present film, Mr. Loeb and Mr. Sourirajan have been able to get potable water at the rate of eight gallons a day per square foot of membrane area. Furthermore, the potable water is produced in a single filtering from a brine containing a 5.25% salt concentration, which is much saltier than ordinary ocean water.

Mr. Loeb and Mr. Sourirajan believe that their process holds possibilities for future large-scale, commercial use, because the film is both cheap and durable, the equipment is simple and can run 24 hours a day without maintenance, and power requirements are as low as for any other desalinization method.

Proudly Presented

Announcing new developments in the chemical industry and newly available chemical literature.

Shrinking Polyethylene Film Through Radiation

➤ THE FIRST commercially successful irradiated plastic film has been announced, making possible new types of packaging not previously employed.

Developed by W. R. Grace & Co.'s CRYOVAC Division after three years of intensive research, the basic process employs a General Electric electron beam generator that bombards polyethylene with up to two million volts. This changes the molecular structure of the polymer and makes possible a new and different plastic film, known as CRYOVAC Type L film, with vastly improved characteristics. One of the most remarkable is its dynamic high-shrink energy.

Especially suited for packaging fruits and vegetables, meat and poultry, bakery and confectionery products, the new film also appears to have a high potential for standard overwrap packaging of many other consumer products in crystal clear skin-tight contour packages.

Polyethylene film is extruded into tape, which is then passed under the eye of an electron beam generator. The generators are located in CRYOVAC's Simpsonville, South Carolina plant, and housed in a 30-foot deep vault insulated by five feet of concrete on all sides. As the electrons hit the tape, the high energy source causes the resulting molecule to become unstable and, therefore, reactive, becoming cross-linked like a tightly woven fish net. This increases the strength of the material more than 500% and makes it possible to stretch the material in both directions more than 200%. After stretching, the film is wound on rolls, and may be printed and slit to size and specification for any packaging application.

The "stretching process," known as biaxial orientation, imparts to the film one of its most dramatic characteristics, its tremendous shrink energy. When exposed to hot air or hot water at 180°, the film immediately shrinks, by 20%, and will continue to shrink equally in all directions as the temperature is increased until it returns to its original size. No other film has ever been manufactured that shrinks to such an extent or with such energy.

This characteristic has made possible the development of new packaging techniques that use the shrink energy of the film to do much of the "wrapping" and sealing of the package itself. Through controlled hot air shrink techniques, the film can be made to shrink itself tightly around the tops of baking pans, produce trays, and even stalks of celery.

Although irradiation is used in the manufacture of CRYOVAC Type L, it would take six million more electron volts than CRYOVAC's equipment is capable of generating to make any film radioactive. This means that the film is as inert immediately after it leaves the generator as it was prior to irradiation, and, from a purely chemical standpoint, is identical with

conventional polyethylene being used on all types of food products.

"Tipersul" Introduced By Du Pont

▶ THE TRADEMARK "Tipersul" has been adopted by the Du Pont Company for fibrous potassium titanate, a new crystalline fiber material for high temperature applications.

"Tipersul" was developed by the company's Pigments Department from fundamental research on new forms of inorganic materials by the company's Central Research Department.

The small, white crystalline fibers are available in lumps and loose fibers, as well as blocks, sheets and paper forms made by standard felting techniques. Curved or odd shapes are also available.

This material, useful to 2200° F., offers low heat conductivity, great ability to scatter infra-red radiation, and low density. These and other properties make "Tipersul" useful for thermal, acoustical, and electrical insulation, as well as for filtration applications. Another significant use for the material is in ablative insulation. Such insulation absorbs heat and limits heat penetration, thus protecting space hardware from high temperatures for brief periods. "Tipersul" may be added as filler to "Teflon" fluorocarbon resins to increase dimensional stability of finished products.

Esso Announces Polypropylene Process

▶ A PROCESS for the production of polypropylene, believed to be the most versatile of all plastics, has been announced by Esso Research and Engineering Company.

The successful completion of the project, requiring a $15,000,000 research and development outlay, enabled the parent firm, Standard Oil Company (New Jersey), and affiliates directly to enter the booming plastics business.

The Esso Research process is a continuous method designed to operate 24 hours a day and is the largest "grass-roots", built from the ground up, polypropylene facility yet constructed. Its initial capacity is 40,000,000 pounds a year and it is designed for expansion to 100,000,000.

The raw material is a refinery gas known as propylene which is altered chemically, by the catalyst and other factors, into a super polymer. The resulting product can be used to make a wide variety of superior, more attractive plastic items.

Molded polypropylene items, such as water tumblers, are both durable and attractive. Films for packaging and wrapping are clear, but glossy and tough, and thus can protect foodstuffs, and serve in other important applications. Various end-uses foreseen include synthetic fibers and piping materials, and scores of other potential polypropylene products are being studied.

A prime advantage of polypropylene is that it retains its basic shape up to 290 degrees Fahrenheit. In fact, it will not melt until the temperature reaches 335 degrees.

In comparison with its earlier-developed cousin, polyethylene, a leading plastic used today, the new material is superior in many respects. It rates higher than the newest types of polyethylene (high density or linear) with regard to rigidity, stress crack-

ing and heat resistance. It can be sterilized in steam under pressure, an attribute making it suitable for hospital equipment.

Polypropylene is economical, too. Because of its light weight, or low density, a pound of polypropylene will go farther, produce more products, than the same amount of polyethylene.

Spectral Data on Organics Available

➤ THE FIRST in a proposed series of spectral data sheets on organic compounds has been published by the Manufacturing Chemist's Association.

The information was compiled by the Carnegie Institute of Technology through a project sponsored by the MCA.

The first issue contains ultraviolet, infrared and mass spectral data. Later issues, to be made available at six-month intervals, will contain Raman and nuclear magnetic resonance spectral data also.

The data on physical and spectral properties is compiled to help industrial laboratories identify processing fractions as well as pure compounds.

The data on spectral properties help in making rapid spectrographic analyses of plant streams and product materials in manufacturing processes, as well as identifying individual compounds in analytical and research work. The data on thermodynamic properties permit the making of reliable calculations of heat balances and evaluation of chemical equilibria occurring in industrial processes.

The MCA-sponsored research on spectral properties was begun at Carnegie on July 1, 1959. It is integrated with the MCA sponsored work on physical and thermodynamic properties initiated in 1955. The spectral project is similar to the American Petroleum Institute Research Project 44 on hydrocarbons and related compounds.

The availability of such data assists industry in utilizing raw materials to greater technological advantage.

An important by-product of this MCA research project is the encouragement of fundamental research on chemical compounds in universities here and abroad. The information is made available to universities free of charge.

Directors of the MCA projects are Dr. Frederick D. Rossini and Dr. Bruno J. Zwolinski. Dr. Alfred Danti is in charge of the work on spectral data. All are Carnegie staff members.

Copies of the spectral data sheets are available on an annual subscription basis at 10 cents each; the physical and thermodynamic data sheets are 5 cents each. Address: Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N.W., Washington 9, D. C.

Silicone Plant Under Construction

➤ GENERAL ELECTRIC has started construction of what is believed will be the most advanced plant in the world for the manufacture of basic silicone intermediate chemicals. The new plant, costing nearly $3 million, will replace smaller existing facilities which will be converted to serve other manufacturing needs at the Company's Silicone Products Department in Waterford, New York.

The new facility will add more than 15,000 square feet of manufacturing space to the Waterford site and will increase capacity for the manufacture of intermediate silicones to beyond 1965 levels. It is expected to go into operation by late 1961 and will utilize the most advanced equipment and technology of the silicone industry. One of its features will be a closed-circuit TV hookup for monitoring operations from a centralized control room.

The main portion of the facility will consist of a six-story outdoor type manufacturing structure, a partial two-story control and general service structure, and storage tank area. Steel and corrugated asbestos construction will be used.

Chemicals to be manufactured in the new plant are silicone intermediates. They are processed by the Company into more than 250 saleable forms of silicone, including silicone rubber, oils, fluids, resins, emulsions and specialty products.

The new plant construction is part of a 24-month, multi-million dollar expansion program involving the addition of new structures, equipment and processes, first announced by the Company in April. The first phase of the program was a $1 million silicone fluids finishing building which is under construction and is expected to go into operation in November.

The Waterford G-E plant is a completely integrated silicone production operation. To meet still increasing demands for masonry water repellents, textile finishes, polishes and cosmetics as well as requirements for silicone rubber in the missile and aircraft industry and other applications, its capacity has been increased steadily since World War II.

The new intermediate plant will be the establishment's eighth manufacturing structure and one of 16 major structures at the site.

New Low Temperature Rubber Developed

➤ The Technical Service Department of the Natural Rubber Bureau announced a new modified Natural Rubber that makes possible Natural Rubber compounds which remain effective at temperatures below —60°C. This latest advance in rubber technology was developed at the Natural Rubber industry laboratories in London, and is the outgrowth of a double-barrelled approach to achieving low-temperature effectiveness:

(1) the incorporation of plasticisers which serve substantially to counteract rapid stiffening that occurs at very low temperatures.

(2) chemical modification of the rubber which results in marked retardation in the slow progressive stiffening that occurs at moderately low temperatures.

The resulting break-through has produced a Natural that now makes possible effective service on window seals, tank tracks, vibration mountings, inner tubes, wire insulation, belts and hose, and other applications connected with high flying aeroplanes, deep freeze equipment, industrial and military items for northern climates and similar sub-zero usages.

The compounding procedures involved, together with a number of pertinent tests, are fully described and

annotated in Technical Bulletin No. 4, Compounding Natural Rubber for Service at Low Temperatures. For a free copy, write Technical Service Department, Natural Rubber Bureau, 1631 K Street, N.W., Washington 6, D. C.

Rocket Fuel Plant To Be Built

➤ A MULTI-MILLION DOLLAR plant for production of anhydrous hydrazine, a rocket and missile fuel, will be built for the Government by Olin Mathieson Chemical Corporation.

The Air Force has placed the project on a high-priority basis. Engineering studies and acquisition of necessary facilities are beginning at once.

The new plant will be built for the Air Force with Government funds and will be operated by Olin Mathieson. The plant's cost, production capacity and personnel requirements have not been disclosed.

Saltville, Va., has been selected as the location for the new plant because of its available raw materials, personnel experienced in chemical production, and nearness to government rocket missile facilities.

Allied To Build Polyether Plant

➤ ALLIED CHEMICAL has announced plans to build a plant for the manufacture of polyethers, making the Company a source for all the major urethane foam components.

Solvay Process Division will begin construction of a new plant at Baton Rouge, La., where it currently produces soda ash, chlorine and caustic soda. Polyethers, which are used for both rigid and flexible foams, will be marketed by National Aniline Division.

Initial capacity will approximate 20 million pounds annually with a unique built-in provision for expanding production rapidly. The plant will utilize propylene oxide as the starting material. Initial production of polyethers is expected to begin by June 1961.

New Tubing Plastic Announced

➤ A SPECIALLY tailored black plastic resin, Marlex TR-212, designed for use in the high quality plastic pipe field, has been announced by Phillips Chemical Company, Bartlesville, Okla.

Phillips reports that pipe extruded from Marlex TR-212 resin has a higher safety factor than any other plastic pipe when extruded to the specifications of the Department of Commerce (Bureau of Standards) and Society of Plastics Industries (SPI) for ASTM Type III Polyethylene. According to exhaustive research data compiled by Phillips over a three-year period, 1″ National Sanitation Foundation (NSF) approved pipe made from its resin sustains a hoop stress of 1800 psi at 1000 hours and 80° F. This is three times the accepted standard design stress for ASTM Type III (high density) polyethylene pipe.

TR-212, easily extruded on conventional equipment, is recommended by the manufacturer for cold water lines.

The light weight and flexibility of pipe extruded from Marlex TR-212 resin makes possible the supplying of coiled pipe. This permits the laying of long lengths with resulting economies in time and labor. The pipe resin is inert to acid or alkaline soil and does not conduct electricity.

New Chemical Patents

To obtain copies of these new patents, order them by number from the Commissioner of Patents, Washington 25, D. C. Enclose 25 cents in coin, money order or Patent Office Coupon (but not stamps) for each patent ordered.

Acid Stomach Checked By Aluminum Salts

➤ UPSET STOMACH is usually due, as everyone must know by now, to overacidity, and there are innumerable pills and potions on the market for the relief thereof. According to Ruth C. Denison of Signal Mountain, Tenn., antacids may be divided into systemic, those that neutralize the offending acids once and for all, and non-systemic, which tie up the acids while they are in the stomach but release them again when they pass into some less acid part of the body such as the small intestine.

Miss Denison favors the latter class, better known perhaps as buffers, and has been awarded patent No. 2,940,898 for a series of antacids consisting of the dihydroxy aluminum salts of various aliphatic organic acids. She assigned her patent to Mrs. John W. Bradley of Lookout Mountain, Tenn.

Solar Cell Measures Meteorite Effect

➤ THE TWO SYSTEMS presently in use to determine the effect of meteoric dust on fast missiles have certain disadvantages. The acoustical method cannot completely distinguish between meteoric noises and those from other sources, and the examination of the surface after recovery does not make it possible to correlate meteoric effects with time and temperature.

John R. Outt of Malvern, Pa., was granted his patent, No. 2,944,250, which he assigned to the General Electric Company of New York, for a means whereby solar cells are set in the surface of the rocket. As the rocket rotates, the current generated by the cell and transmitted back to earth will vary from zero to maximum. The abrasive effect of meteors on the cell surface will cause drops in power which will be indicated as dips on the current-time curve.

New Drugs May Eliminate TB

➤ A CLASS OF chemical compounds that is highly effective against bacteria, has a low degree of toxicity and can, under proper conditions, eliminate tuberculosis in humans and animals has been patented.

Until relatively recently the treatment for TB depended upon the natural recuperative powers of the body, and consisted of fresh air, rest and good nursing. The cure was by no means certain and often took years.

Recently such drugs as streptomycin have been found to be effective. However, they have, according to Dr. Peter P. T. Sah of the University of California School of Veterinary Medicine, Davis, Calif., certain shortcomings. They are toxic and the tolerable dose may only be enough to inhibit the disease but not destroy the disease

germs; they are not effective against some forms of TB, and the TB bacilli can develop a resistance to the drugs.

Dr. Sah was granted patent No. 2,940,899, which he assigned to the University of California, Berkeley, for his method of treating TB with a chemical called d-galacturonic acid isonicotinyl hydrazone or one of a group of related compounds, and for various methods of their preparation.

These drugs have, according to the inventor, much lower toxicities than those now in use, and may therefore be safely used in sufficient doses to destroy the TB bacilli without causing harmful side effects.

Gibberellin Increases Livestock Yields

➤ GIBBERELLIN, a non-antibiotic material that increases the growth rate of plants, may be added to animal feed to give better and faster yields. John R. De Zeeuw, Gerald A. Donovan and William C. Sherman, all of Terre Haute, Ind., were awarded patent No. 2,943,938 for this use of gibberellin. They assigned it to Chas. Pfizer and Co., Inc., of New York.

They said that the addition of very small amounts of gibberellin, between one part in a billion and one in a million, is especially effective in increasing the growth rate of poultry and is also effective for cattle, sheep, pigs, lambs and other farm animals.

The use of various hormones, and of antibiotics, in animal feeds is not new, but according to the inventors, gibberellin, a term they use to include the three compounds known specifically as gibberellins A-1, A-2, and A-3, is much more effective than such previously used materials as penicillin and stilbestrol, in promoting growth. Since it is not an antibiotic, gibberellin does not reduce the incidence of disease, as does penicillin for example, so these other additives may still be necessary in some cases.

Cigarettes From Alfalfa and Cornsilk

➤ CIGARETTES have been made from cornsilk and alfalfa before, but, according to Gerald M. Schaflander of Fresh Meadows, N. Y., they have all had a rather acrid taste. Smoking mixtures made from these components do, however, have very little tar and no nicotine at all.

Mr. Schaflander has discovered a means of removing these unpleasant properties according to which the mixture is washed with water and then treated with steam which extracts the chemicals responsible for the acridity. The fibers are finally treated with an aldose solution and dried. The inventor assigned his patent, No. 2,943,958, to Bantob Products Corp. of New York.

New Process For Synthetic Garnet

➤ ALTHOUGH garnet is a fairly abundant mineral in the U. S., it is usually found well mixed with many other minerals, so that obtaining pure natural garnet can be a long and tedious business. Robert H. Wentorf, Jr., of Schenectady, N. Y., has therefore discovered a means of making artificial garnet, reported to be chemically indistinguishable from the real thing, from hornblende, a much more common mineral which can easily be obtained in the pure state.

Dr. Wentorf's process, patent No. 2,941,861, consists of heating a mixture of the hornblende and a metal dehydrator to temperatures of at least 1,250 degrees centigrade while under pressures of 27,000 to 40,000 atmospheres. He assigned the patent to General Electric Company of New York.

Process Makes Toothbrushes Bactericidal and Germicidal

➤ PATENT No. 2,939,164 was awarded to Murray W. Rosenthal of Nutley, N. J., for his method of treating toothbrushes to give them germicidal and active bactericidal properties throughout their normal useful lives. Mr. Rosenthal assigned his invention to Pycope, Inc., of Jersey City, N. J.

The treatment consists of immersing the toothbrushes, or their parts, in a colloidal solution of an aromatic mercury compound, virtually insoluble in water, and a bactericidal quaternary ammonium compound.

Tests on treated toothbrushes in daily use have shown that the germicidal and bactericidal properties remained effective over a six-month period.



"We never made such a fuss when our figures balanced!"

For the Home Lab

Molybdenum

by Burton L. Hawk

➤ Molybdenum occurs in nature as the sulfide, a black mineral similar to graphite in appearance. So similar, in fact, that it was sold as graphite for many years. Finally, in 1778 the famous chemist Scheele proved that these two materials were not the same. He found that one reacted with nitric acid to form a white powder whereas the other was not affected whatever by the acid. Since he could not identify the white material, he rightly assumed that it must be the oxide of a new element. The next step was to try to obtain the element by the tried-and-true method of reducing with carbon. This reduction was carried out successfully by Scheele's friend, Peter Jacob Hjelm, who was the first one to observe the gray powdered molybdenum.

The Metal

Molybdenum is a silver-white metal, fairly resistant to oxidation and quite resistant to pronounciation. Molybdenum melts at 2600 degrees which makes it difficult to work. Because of this high melting point it is always obtained as a powder. It is converted to a coherent metal by compression, as is tungsten. Its chief use is in the filament supports of electric light bulbs and electronic tubes.

Reduction of molybdic oxide produces the metal. In the home lab, carbon requires too high temperatures and hydrogen is too dangerous. Thus reduction with aluminum by the thermit process is preferable.

You will probably have difficulty in procuring molybdic oxide, so we will use molybdic acid- 85% as our starting point. This material, which is readily available, contains the oxide along with ammonium molybdate. Place one or two grams of molybdic acid in a crucible and apply heat. Continue heating, with occasional stirring, until a bluish gray powder is obtained. Perhaps you will notice the odor of ammonia, as this is evolved during the heating. (If molybdic acid is not available, you may use ammonium molybdate instead. Heat slowly at first to drive off the water, then gradually increase the heat). Place the blue powder in a mortar and grind as finely as possible. Now add an equal quantity of powdered aluminum and grind the two materials thoroughly together. Transfer the mixed powders to a large clay crucible. Carefully sprinkle on top of the mixture a small amount of ignition powder consisting of powdered magnesium mixed with barium peroxide. Set the crucible in a spot where no danger can occur from flying sparks or flames. Now, using a long tongs, ignite a piece of magnesium ribbon and drop the burning ribbon into the crucible. *Keep your face away!* The reaction will be quick and violent.

After the crucible has completely cooled, scrape the contents out and drop them into a solution of dilute hydrochloric acid in a flask or beaker. If the action is slow, apply heat. Allow the acid to react with the residue

for quite some time. This will dissolve the unreacted aluminum, magnesium, and also the aluminum oxide formed. Finally filter off the acid, wash the residue and examine it with a magnifying lens. The gray powder should contain molybdenum; however, the success of this experiment is not guaranteed. The volatility of the molybdic oxide will sometimes prevent an effective reduction. (Be sure to use only small quantities when performing this reaction).

Colorful Compounds

The chemistry of the compounds of molybdenum is quite complicated. Molybdic acid tends to form salts of isopoly and hetero-poly acids. For example, salts of iso-poly acids with up to 24 molybdenum atoms have been described. The "normal" molybdates are salts of H_2MoO_4. From these, by treatment with nitric acid, the paramolybdates are derived. The regular ammonium molybdate of commerce is actually ammonium paramolybdate hexahydrate. Be that as it may, let us proceed with our experimenting and leave the technicalities for the text books.

Ammonium molybdate forms a characteristic yellow color with phosphates which serves as a test for the latter. Prepare a solution of ammonium molybdate and make it strongly acid by the addition of nitric acid. Add this to a solution of sodium or calcium phosphate. Upon heating a yellow powdery precipitate is produced. This is ammonium phosphomolybdate.

Prepare a solution of stannous chloride and add a small quantity of dilute hydrochloric acid. Upon the addition of ammonium molybdate solution, an intense blue color is obtained. This is "molybdenum blue," formed by the reducing action of the stannous chloride. This is another one of those complex compounds of which the definite composition is questionable. There is a "blue oxide" of variable composition formed when molybdic oxide is reduced. For example, if molybdic acid is reduced in sulfuric acid with tin or zinc, the blue color is obtained if the concentration of the acid is between 25 and 75 per cent. If the solution is diluted to less than 25% acid, the blue color disappears. The blue color will also disappear on heating, but will return on cooling. Well, so it goes . . . you figure it out!

Add a solution of sodium thiosulfate to a solution of ammonium molybdate. Nothing happens. Now add a few drops of hydrochloric acid. A light blue color is obtained which darkens upon standing. Additional acid will produce a darker color and still more acid will produce a brown color.

Add a solution of potassium thiocyanate to a solution of ammonium molybdate. Follow this with a few drops of hydrochloric acid. A yellow color is obtained. Drop in a piece of zinc. A beautiful red color is formed and arises in a cloud from the zinc. As the zinc dissolves, the color darkens and spreads throughout the solution. This is quite an unusual effect.

Add a solution of potassium ferrocyanide to a solution of ammonium molybdate. Upon acidifying with a few drops of hydrochloric acid, a deep red precipitate is rapidly formed.

Add a solution of tannic acid to a solution of ammonium molybdate. A lovely deep orange color is obtained.

For a beautiful demonstration of

reduction by stages, add dilute hydrochloric acid and a piece of zinc to a solution of ammonium molybdate. As the zinc starts to react, a pastel shade of blue is formed. It gradually turns darker. As the action proceeds, various shades of blue and blue-green are obtained, and thence a full green color. Finally, the green passes through a multitude of shades into a deep brown color.

This series of color changes is typical of molybdates. You may experiment with other reducing agents upon ammonium molybdate. Under certain conditions and dilutions of zinc and HCl reductions, successive changes of yellow, red, green, and brown are obtained.

Molybdenum forms five oxides (three "sure," two "questionable"); five sulfides, four chlorides, three fluorides, two oxyfluorides, three bromides, and two iodides. No normal sulfate is known. However, when a solution of molybdic acid in sulfuric acid is electrolyzed, the usual color change is obtained (this time from pink to green). What is this material? It has been thought to have a general composition of $MoO_3 2SO_3 5H_2O$. If molybdic acid be added to hot concentrated sulfuric acid colorless crystals are obtained which are very unstable. This compound is thought to be MoO_2SO_4.

Ammonium molybdate can be prepared by dissolving the trioxide (molybdic oxide) in ammonium hydroxide and evaporating the solution. Conversely, the trioxide can be obtained from ammonium molybdate by heating the dry compound.

Anyone that is of the opinion that inorganic chemistry is "simple" should tackle a study of the compounds of molybdenum. To those who may be interested, the unraveling of these extremely complex compounds presents a real challenge.

Columbium Toughens Steel Pipe

➤ Adding small amounts of columbium to steel during its manufacture has been found to strengthen it and to make welding easier.

With the rapid expansion of the natural gas industry, there has grown a demand for a steel suitable for the construction of long-distance, trouble-free pressure pipelines.

Higher gas pressures in these pipelines has dictated use of higher strength steels. These have usually involved high carbon contents, resulting in more brittle steels and great welding difficulties, especially at low temperatures.

This problem has now been solved by the Great Lakes Steel Corporation, Detroit, a division of the National Steel Corporation. Great Lakes will produce a new family of steels containing columbium.

These steels, although developed for use in gas pipelines, have already generated wide interest because of their possible use in truck frames, highway lamp posts and railroad equipment.

Making the steels economically attractive is the fact that the price of columbium has dropped over the last 10 years and large deposits of columbium were recently discovered in Quebec.

√ *Chemistry Quiz* √

Directions: Mark the answer you think *most nearly correct.*
Answers are on page 33.

A. The following is *not* typical of colloidal solutions
   1. Tyndall effect
   2. Brownian movement
   3. Percolation
   4. Electric charge

B. The most commonly used process for the mining of sulfur is known as
   1. The Sicilian process
   2. The Frasch process
   3. Hot bedding
   4. The Fischer-Hund process

C. Anaerobic bacteria
   1. Live only in salt water
   2. Can live without oxygen
   3. Are harmful to man
   4. Are not found in nature but can be obtained by the chemical modification of certain natural bacteria

D. Of the following metals, the only one not found free in nature is
   1. Gold
   2. Platinum
   3. Copper
   4. Zinc

E. One might expect to find *karaya gum* as a component of
   1. Rubber cement
   2. Cigars
   3. Toothpaste
   4. Bubble gum

Complete copies (with answers and norms) of many previous Science Talent Search examinations are available at 15c each from Science Service, 1719 N St., N.W., Washington 6, D. C.

Water Vapor on Venus

➤ WATER VAPOR in the atmosphere of Venus below the cloud level is more abundant than has been thought, a Johns Hopkins University scientist has reported.

Dr. John Strong told an Optical Society of America meeting that water vapor in the atmosphere of Venus was measured by scientists studying records of the planet made from a manned balloon flying some 15 miles above the earth's surface in November, 1959.

Other scientists have suggested this finding raises the possibility that some sort of life could exist on Venus.

Instruments carried in the balloon were designed by Dr. Strong. The balloonists were Cdr. Malcolm Ross of the Office of Naval Research and Dr. Charles B. Moore of Arthur D. Little, Inc., Cambridge, Mass.

Finding water vapor in the atmosphere of Venus is the first indication of water on the planet, which is known to have a great deal of carbon dioxide in its atmosphere.

The amount of water measured in the Venus atmosphere is about four times more than found in the earth's stratosphere, and is about the same as above high level clouds on earth.

Science Talent Search
Project Report

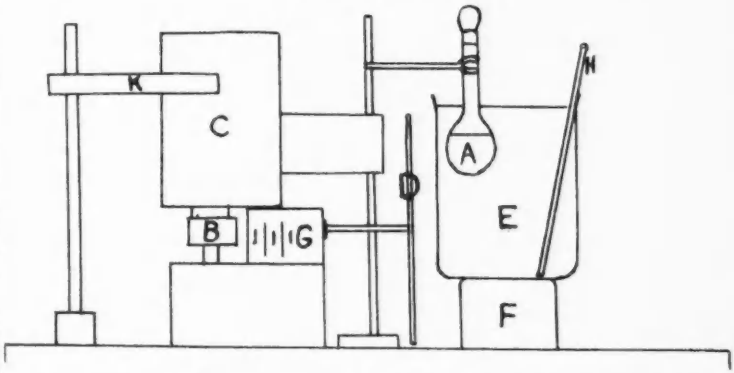
Half-Life of Free Radicals

by JOYCE A. THOMPSON
Stonewall Jackson High School, Charleston, West Virginia

Joyce Thompson, 17, was a winner in the 19th Science Talent Search. She hopes to major in chemistry at university with a view to becoming a research chemist.

POLYMERIZATION by free radicals is the most important process employed in the rapidly growing plastics industry. Through reading and talking to polymer chemists I became interested in discovering just how free radicals behave. These very unstable radicals can exist for only very short times before combining either with other molecules or other radicals.

My first step in developing a project on free radcials was to find out their structure and what causes them to form. The most common sources of free radicals are organic peroxides. When ultraviolet light passes through certain peroxides the molecules split at the oxygen double bonds and become free radicals. Using ultraviolet light to produce radicals seemed the best way for me to carry out my experiment. I had, therefore, to set up an apparatus that would produce enough radicals to be measured.



THE APPARATUS *finally used by Joyce Thompson in her project is here shown in diagramatic form. A is the reaction mixture of monomer and peroxide, B is the mercury lamp, C is a shield to protect the eyes from U. V. radiation, D is a sectored wheel (see photograph), and E is a cooling bath. F is a magnetic stirrer, G is the motor which drives the sectored wheel, H is a thermometer, and K is a cathetometer.*



➤ JOYCE THOMPSON *is shown with her display at an exhibition held in Washington as part of the 19th Science Talent Search. Joyce was one of the 40 S. T. S. winners chosen from over 29,000 high school seniors throughout the United States.*

I chose dibenzoyl peroxide as my radical-former since ultraviolet light was supposed to break it up comparatively easily. Then I decided on acrylonitrile as the monomer to be used because it would react readily with the peroxide radical to form a polymer which was insoluble in the monomer and therefore easily seen. I used a special 100 watt mercury arc as the source of the ultraviolet light and devised a shield from a tin can to block off the light and protect my eyes, since light from such a source can be damaging to the sight.

Apparatus

The first apparatus I tried was not successful because, in the time needed for the radical to pass from the point of formation into the monomer, the radicals would recombine with each other. Evidently the life of the radical was so short that the only way polymer could be produced would be to dissolve the radical-former in the monomer and then train the light on the mixture to form radicals right in the monomer.

My second apparatus was more successful. At least, radicals were ob-

viously produced because polymer was formed. However, this time the problem was that the polymer was formed so rapidly that the polymerization temperature went out of control. Polymer virtually exploded from the volumetric flask. This problem was easily remedied by placing the flask in a bath of ice water with a magnetic stirrer to keep the water circulating and the temperature constant.

Now that I had a means of producing free radicals, I had to find a method of determining their half-life. It appeared that this problem could be solved by using a method developed by Dr. H. W. Melville in England. With this method the steady flow of ultraviolet light is broken up into light flickers. The rate of polymerization then varies with the flickering rate. By plotting the rate of polymerization against the flickering rate I could determine the half-life of the radical.

To obtain this flickering light I placed a motor-driven wheel directly in front of the mercury arc, as shown in the diagram. This wheel would completely block all the light when a sector was in front of the lamp but allowed the full flow of light to penetrate the flask when an open section was in front of the lamp. A different rate of flickering was obtained with a second wheel I made with sectors half the size of those of the first.

The polymerization rate was determined by measuring the amount of polymer formed in the flask as the polymerization proceeded. This was done by measuring the change in the volume during the polymerization, using a small cathetometer. The volume of material in the flask decreases as polymer is formed. This occurs because the double bond of the monomer occupies more volume than the single bond of the polymer. Therefore the density of the polymer is greater and the volume less than that of the monomer.

So far I have made use of only two sectored wheels, but I plan to continue with my experiments and run several trials with several wheels of varied design. Another motor must also be used to obtain a really wide range of flickering speeds.

I have not run enough trials to enable me to make a graph which will allow me to calculate the half-life, but when I have completed more trials I should be able to obtain a graph similar to that platted by Melville in his work on free radicals.

I believe that the knowledge of the half-life of various free radicals will enable the polymer chemist to choose the most suitable radical for his needs — the one which will produce the desired polymer, has the greatest reactivity, and is the least expensive. I hope my efforts will be of value in acquiring this knowledge.

√ Answers to CHEMISTRY QUIZ on Page 30. √

A - 3; B - 2; C - 2; D - 4; E - 3.

Tires of The Future

➤ An exciting tire-of-tomorrow, with performance and wear far beyond present levels, may be evolving from research in five synthetic fibers.

A program of research and testing in quest of a tire that will combine exceptionally long life with smooth and quiet riding properties is being conducted by the Goodyear Tire and Rubber Company.

"The potential of these fibers is striking in terms of the qualities they may enable us to build into tires," said Dr. R. P. Dinsmore, vice president in charge of research for Goodyear.

"For example," he said, "one has a melting point of 600 degrees Fahrenheit, compared with 482 degrees for the fiber used in today's premium replacement tires."

Research in new fabrics includes building them into test tires which are put through severe punishment on special machinery and high speed test tracks. In addition, the tires are run thousands of miles over regular road surfaces, from turnpikes to city streets. The test tires are analyzed to measure such factors as the fibers' resistance to heat and fatigue.

The new fibers fall under three general classifications — polyester, polyvinyl and polyamide. So far all of the fibers show great promise.

Fibers, woven into fabrics, are used in the construction of casings — the very backbone of tires. Just how much a tire can take in the way of shock, stress, and heat generated by flexing and high speed depends to a large extent upon its casing.

The natural and synthetic rubbers, too, are important in the life and performance of a tire. But so integral are the parts of a tire that no one component can advance unless the others accompany it.

Fibers and fabrics now in use in the rubber industry are quite adequate for today's tires. In seeking new ones, Dr. Dinsmore said, "we are preparing for the day when higher speeds and horsepower could make current tires fibers as obsolete as the carriage wheel."

In the polyester group, Goodyear is studying Vycron, Terylene and Dacron. The company last year opened a new polyester plant at Point Pleasant, W. Va., which has an annual capacity of 10 million pounds of vitel, the resin used by Beaunit Mills, Inc., in making Vycron fiber.

Terylene is a product of Imperial Chemical Industries, Ltd., and Dacron is made by E. I. duPont de Nemours & Co., Inc.

The major advantage of the polyester fibers is a uniformity and dimensional stability that would enhance the smooth-running properties of tires.

The fourth fiber in the research program is Vinal, a polyvinyl developed in Japan and now licensed exclusively for the Air Reduction Chemical Co. Vinal has excellent resistance to separations from heat and speed and shows particularly good adhesive properties.

HT-1, which belongs to the polyamide family with nylon, is made by duPont. It is the fiber with the melting point of 600 degrees F.

"This heat-resistant factor will be of tremendous importance to the tire industry once we harness it into application," Dinsmore said. "We have made encouraging progress in this direction."

In any use of new fabrics for tire building, adhesion is one of the prime considerations.

Before any new fabric may be used, an adhesive must be developed with which it can bond. Then comes the second step — making the adhesive layer bond 'on the other side' with the rubber in the tire.

Each change necessitates other changes that may extend even into the tread design of the tire.

"With each of the new fibers," Dr. Dinsmore added, "we have found many promising leads toward solution of the adhesion problem."

Synthetic Talc Prepared In Bulk

➤ MAGNESIUM SILICATE, familiar to the layman as the natural minerals talc and asbestos, is now being made by a purely synthetic process.

This process, developed by the A.I.C. Chemical Company and now being used at their plant in Butler, N. J., is reported to be the only one of its kind in the United States, according to the industrial magazine Chemical Processing.

Magnesium chloride solution is prepared from magnesium hydroxide and hydrochloric acid and is then mixed with a solution of sodium silicate in sodium hydroxide solution. Magnesium silicate is formed as an insoluble precipitate which is filtered out, washed several times, and dried.

The synthetic material is at present more expensive than its natural counterpart, however, it does have certain advantages over the natural mineral. These are its very high, yet selective, absorbtive powers, and its strong affinity for polar and acidic compounds, which make the compound especially suitable for purification and other separation processes.

The product is a voluminous white powder, similar to baby's talcum powder (without the perfume of course). It is chemically inert, that is it will not react with most other chemicals, and it is insoluble in water and most other solvents.

USSR Develops Strong Glass

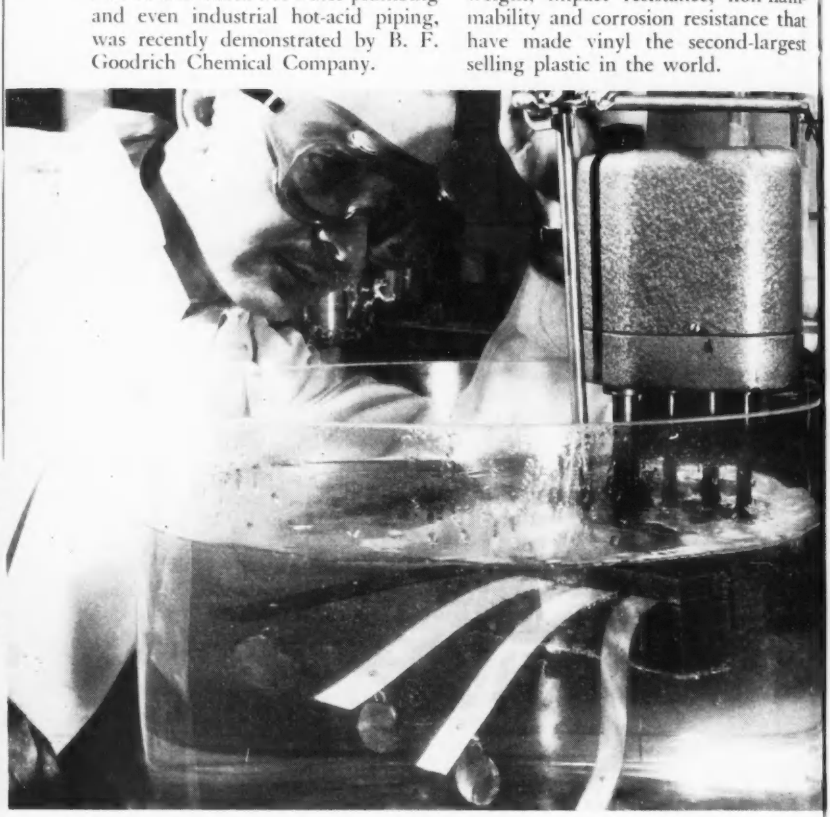
➤ RUSSIAN WORKERS at the experimental department of the factory Avtosteklo (Autoglass) have developed a strong new material, glassporcelain. It is made from glass by a special heat treatment. This material is intended for manufacturing insulators, window sills, stair steps, floor tiles, and pipes.

The glassporcelain has very high bending strength, and is resistant to temperatures up to 572 degrees F.

New Vinyl Resists Heat

➤ A NEW VINYL plastic that can withstand temperatures 60 degrees higher than conventional vinyls, and can be used in household hot-water plumbing and even industrial hot-acid piping, was recently demonstrated by B. F. Goodrich Chemical Company.

The new material, a polyvinyl dichloride called hi-temp Geon, retains all the qualities of strength, light weight, impact resistance, non-flammability and corrosion resistance that have made vinyl the second-largest selling plastic in the world.



➤ WEIGHTED *sample strips of various plastics are subjected to 180-degree water to test their heat resistance. Strips one, two and three, from right to left, are conventional vinyl, high-density polyethylene and polyamide, respectively. B. F. Goodrich Chemical Company's new hi-temp Geon, farthest to the left, is meeting this heat test without the slightest sag.*

The addition of high heat resistance, never before achieved in a vinyl material, opens new horizons for vinyl. Among other things, the hi-temp factor means that, for the first time, vinyl can take over functions in the building, chemical processing, and automotive industries that previously were the exclusive domain of metals.

Hi-temp Geon is now in pilot-plant production and will be available in limited quantities until commercial production facilities are completed next year.

Hi-temp Geon's light weight and ease of installation, coupled with the new heat resistance, makes it suitable for use in prefabricated kitchen and bathroom piping facilities that are easily transportable.

Based on the potential of the market now going to copper and galvanized pipe, the market for pipe made of this new material could reach many millions of pounds in a relatively short time. Domestic industry-wide sales of conventional vinyl resins in 1960 are estimated at a record 880 million pounds.

In view of the initial price of this new material, it is expected that the price of pipe made from hi-temp Geon will be no more than or slightly less than that of copper pipe. In the plastics industry, a price reduction is generally made once commercial production gets under way.

Hi-temp Geon is compounded to withstand operating temperatures from 180 degrees F to 200 degrees F, along with pressures up to 150 pounds per square inch. Normal household pressure is 50 to 60 psi.

One-sixth the weight of copper, hi-temp Geon makes possible prefabricated plumbing walls which may be trucked to job sites easily and swung into position by light cranes. A two-story installation is already functioning in the National Association of Home Builders' research house at East Lansing, Mich.

Hi-temp Geon can be molded, extruded and heat-formed on standard plastic processing equipment.

B. F. Goodrich Chemical Company supplies only the resin materials and technology for the new process. The company does not manufacture pipe or any other finished products, but it is working with several leading pipe manufacturers to bring this innovation to the market.

Lunar Water Supply

➤ MAN'S WATER supply problem on the moon might be solved by a process of extracting water from volcanic rock, according to a research geologist from the Aero-Space Laboratories of North American Aviation's Missile Division, Downey, California.

This process, now being tested at the Aero-Space Laboratories, is still in its early stages and presumes the existence of volcanic lunar rock, reported Dr. Jack Green, who heads the experiment.

In this event, there would be a possibility of finding pitchstone or other hydrous rocks on the lunar surface. One variety of volcanic rock, pitchstone often contains 5% water by weight, or the equivalent of one gallon per cubic foot.

The objective of the program is to measure the efficiency of recovering water from hydrous rocks through the use of solar energy. Dr. Green said that if this process is effective on earth it would be even more efficient on the moon because of the greater solar energy there.

Dr. Green pointed out that the method of extracting the water is comparatively simple. The necessary ingredients are crushed pitchstone, a Fresnel lens, an enclosed metal container for the rock and a cold trap arrangement.

For the experiment, the pitchstone, varying in grains ranging from one-sixteenth of one millimeter in diameter to one millimeter in diameter, is placed in a container in which a vacuum is drawn. It is preheated to 212 degrees Fahrenheit, the maximum lunar temperature, to simulate the environment of the moon. The water in the pitchstone is extracted at temperatures in excess of 230 degrees.

The lens is mounted above the crushed rock in a manner similar to that used in starting a fire with a magnifying glass. The sun's rays are focused on the rock through the lens, causing the water in the rock to vaporize. The steam is then condensed in the cold trap and collected.

Dr. Green said the Fresnel lens is ideal for this type operation. It weighs only three ounces, has a 14-inch focal length, is about 14 inches in diameter, and can generate a temperature of 2000 degrees Fahrenheit at its three-eights of an inch focal point. Due to its plastic composition, the lens is extremely portable, unbreakable, easily packaged and would lend itself well to a survival kit type operation.

In addition to being suitable for human and agricultural use, the water extracted from the pitchstone conceivably could be decomposed by solar energy, yielding hydrogen and oxygen. These elements could be used for fuel for a return trip to earth.

On the Back Cover

➤ OUR BACK COVER *shows Robert Miller, Boeing flight test engineer, with the realistic imitation ice formations, simulating the effect of severe icing conditions on airfoil leading edges, which have enabled Boeing Transport Division engineers at Seattle to furnish proof that the 707 jetliner can operate in safety with one-third of its tail de-icing equipment inoperative.*

The melt-proof ice is in the form of fiberglass-covered styrofoam slippers. They fit snugly over de-icing equipment on the leading edges of the 707's vertical fin and left horizontal stabilizer to duplicate the formation of heavy rime ice. The slippers were designed after study of photos of icing on airplane leading edges.

Flight tested over a full range of operating conditions, including low to high speeds, takeoff and landing, the 'ice' slippers were found to slightly increase drag but did not interfere with control, maneuverability or safe operation. Also, they eliminated the problem of finding suitable natural icing test conditions aloft. Test results were given to Federal Aviation Agency officials for approval.

Mossbauer Effect Investigated

▶ Low energy gamma rays given off by the exploding atoms of certain radioactive elements hold the key to discovering many of the remaining secrets of atoms.

They also provide the most precise nuclear clock yet available, one that might keep time accurately within at least a hundredth of a tick in a million million.

Scientists know this new discovery as the "Mossbauer effect," after the German physicist, Prof. R. L. Mossbauer, now at California Institute of Technology.

With a device using this effect, two Harvard University physicists recently made a conclusive test of Einstein's general theory of relativity. They found that the principle of equivalence is true for electromagnetic waves such as radio and light.

According to the principle of equivalence, there is no detectable difference between the force of gravity and the force produced by acceleration in the absence of a gravitational field.

To confirm this gravitational red shift, the Harvard scientists, Prof. Robert V. Pound and Glen A. Rebka, Jr., measured the change in frequency of gamma rays given off by iron-57 as the radioactive source was moved up and down a 70-foot column.

Now three scientists at the Los Alamos Scientific Laboratory in New Mexico report they have found another material, zinc-67, that appears to exhibit the "Mossbauer effect" at a level some three times that of iron-57.

The gamma ray radiation involved in the Mossbauer effect has a frequency that is very much more stable than that now available from the best atomic clocks. The electromagnetic waves involved have frequencies of some million million million cycles per second, so ordinary radio methods for observing their frequency stability do not work.

However, Prof. Mossbauer discovered that he could use an absorber that was similar to the radioactive source to detect the frequency change.

Prior to the discovery of the Mossbauer effect, scientists thought the best way to check the gravitational red shift predicted by Einstein's general theory of relativity would be to put an atomic clock in an earth satellite.

The Mossbauer effect was discovered only recently because certain secondary effects made it quite difficult to observe the nuclear resonance involved.

The Los Alamos scientists who reported the gamma ray resonance of zinc-67 are Drs. D. E. Nagle, P. P. Craig and W. E. Keller.

Now that one important relativity question is settled, scientists are testing for other experiments that capitalize on this very precisely defined electromagnetic frequency.

The Mossbauer effect has provided them with a powerful tool for the exploration of many of the remaining secrets of atomic physics, according to Dr. Winston E. Kock of Bendix Corporation's research laboratories in Detroit.

Curium in Preparation

➤ In one of the giant atomic reactors at Savannah River, S. C., about 12 kilograms of plutonium, fission bomb element, is being bombarded with neutrons.

Two or three years hence chemists will extract the world's largest quantity of the extremely rare man-made chemical element californium, number 98, a matter of only a milligram.

This will be a major step toward understanding and possibly using the heaviest known elements that can be converted in a step by step process of successive transmutation into heavier elements.

This promises also to lead to the creation of still-undiscovered element 103 and still heavier elements.

Dr. Glenn T. Seaborg, Nobelist, discoverer of many of the transuranium elements of the atomic age, who is now chancellor of the University of California, Berkeley, described the new long-range national program to produce research quantities of synthetic elements 97, 98 and 99 in receiving the Dickinson College 1960 Priestley Memorial Award.

Dr. Seaborg proposed at the same time that the new program be expanded into an international effort at the U. N.'s International Atomic Energy Agency in Vienna, with scientists from other nations, including Russia, participating.

About 100 grams of curium, element 96, will be produced by 1963 in the first step, along with other heavy elements.

By that time, the University of California is expected to have a high flux neutron reactor, part of the current proposed program of the Atomic Energy Commission. The curium, much more than ever produced before, will be subjected to the extremely high concentration of neutrons that will be created in the new reactor. At the end of two or three more years further transmutations will have occurred, and there will be extracted about a milligram of californium.

A milligram of californium will be many times more than scientists have ever been able to assemble.

Part of it will be used, for example, as a target material in atom-smashers like the Berkeley HILAC, in which Dr. Albert Ghiorso, of the Lawrence Radiation Laboratory, would attempt to create element 103.

Out of the discovery of such new elements and chemical and other studies of the properties of the extremely heavy nuclei will come refinements of knowledge of the heavy atomic nuclei the value of which cannot be calculated.

In proposing that the program be made international, Dr. Seaborg said: "The program meets all the criteria for international development. There is nothing more basic or more international than the chemical elements. They are the elementary stuff of the universe. These heavy ones have no military value. Making the heavy ones is extremely expensive. If we can include scientists from other countries in the program, and provide them with some of the materials we will make a valuable contribution to the expansion of human knowledge and international understanding."

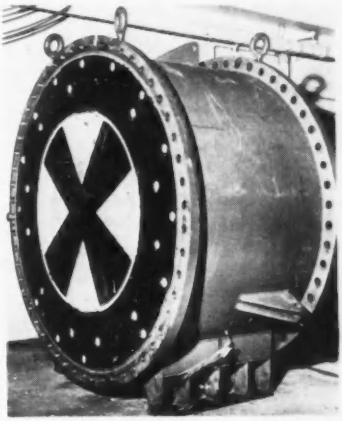
Solid Fuel Engines Segmented

➤ PRESENT technology makes it possible to design a solid propellant booster rocket motor many times more powerful than the motors now being used in our nation's intercontinental ballistic missile programs, according to Mr. Bryce Wilhite, Technical Director for Thiokol Chemical Corporation's Rocket Operations Center, Ogden, Utah. This huge booster could play an important part in this country's space program and be available within two to three years' time.

Mr. Wilhite outlined different techniques that could be used to produce a large solid propellant booster with sufficient thrust to lift heavy payloads into orbit or to the moon. These methods include segmented engine casting and on-site loading.

It has been reported that the limitations imposed on the size and performance of rocket engines are associated with problems of logistics. These include building the large metal parts, constructing required processing and launching facilities and, perhaps most important, transporting large engines from construction plants to launch sites over already inadequate road systems. Mr. Wilhite explained these limitations were largely academic. The segmented engine casting method, for example, was proven feasible during work accomplished by Thiokol in 1952 on the Loki missile propulsion system designed and developed by Jet Propulsion Laboratories. The Loki engine was built in two segments, a cylindrical portion and a head-end. These parts were then assembled by fitting the cylindrical portion over the head-end segment. Studies conducted in 1956 proved that several cylindrical segments could just as easily be used to build larger engines.

One method was used to prove that several cylindrical sections, using "U"



➤ SHOWN ABOVE *is a huge slice (70 inches) of a large solid fuel motor. It was cast at the Redstone Division, Thiokol Chemical Corporation, Huntsville, Alabama, where studies in segmented casting have proved the technique feasible for building larger motors. In the segmented casting technique motors are cast in several separate sections which are later joined together to form the complete motor. Due to problems associated with handling each segment as a separate engine and the insulation and protecting of joint surfaces, on-site loading is recommended as a more feasible method for building the multimillion lb. thrust motors currently being proposed for space application.*

shaped expansion joint seals, could be successfully attached to build one large engine.

A second method was used to demonstrate that an engine case could be assembled from segments and loaded as a single engine.

Both of these programs were conducted at Thiokol's Redstone Division. Both were successful. In fact, an engine measuring approximately six feet in diameter was successfully cast in a segmented case.

The problems associated with handling each segment as a separate engine, and insulating and protecting the joint surfaces seemed to indicate that on-site loading would be more favorable.

The on-site loading technique requires the loading, curing and assembly of the solid propellant engine at the launching site, or close enough to the site so that the problem of transportation is not too important. The propellant for the engine would be mixed at a nearby processing plant or by a portable continuous mixer.

Foil Strains Seen on Atomic Scale

➤ USING AN ELECTRON transmission microscope and motion picture techniques, research workers at the University of Cambridge are now able to watch what actually happens to metal foils when they are strained to breaking point. Dr. P. B. Hirsch and Prof. A. H. Cottrell, both of Cambridge, have found that structures "virtually down to the atomic scale can be seen for the first time."

They hope the method will enable scientists to understand thoroughly how the engineering properties of solids result from atomic structures.

The new technique has been used, for example, to watch what happens when a pure metal is suddenly cooled from high temperatures, to find out how nuclear radiation damages metallic crystal structures, and to follow the arrangements and dislocations that occur when a metal foil is gradually strained to its breaking point.

Exotic A-Fuels from Pressure

➤ NEW AND EXOTIC reactor fuels are foreseen as the possible offspring of further research into the effects of high pressures and temperatures on materials.

C. M. Schwartz, Battelle Memorial Institute, Columbus, Ohio, told an American Institute of Chemical Engineers meeting that the application of ultra high pressures should become an important tool in promoting changes and reactions in materials.

The resulting materials often would have unusual qualities. Many could be expected to have higher densities, and hardnesses.

As the pressure and temperature capabilities of the research equipment is improved, "there is little doubt that new materials having unique properties will be synthesized," Mr. Schwartz said. The outlook is equally promising in the fields of organic and inorganic chemistry.

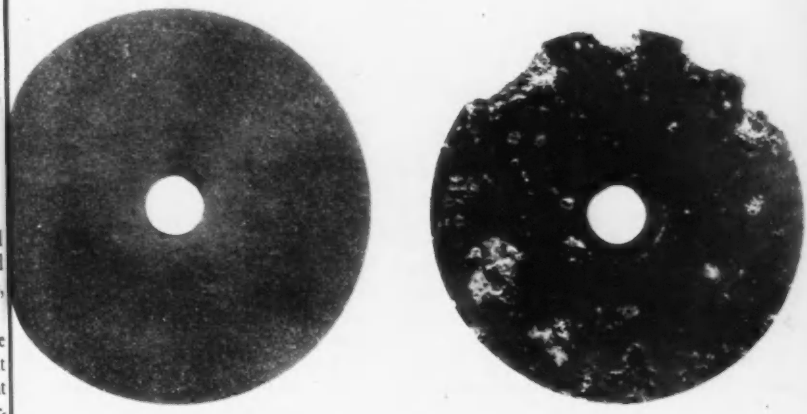
Ti-Pd Alloy Resists Corrosion

➤ THE EXCELLENT corrosion resistance of titanium-0.2% palladium alloy has been confirmed by recent tests in reducing-type environments at a nuclear research laboratory and in the plant of a chlorine chemical producer.

While experiments in many corrosive media were conducted as the alloy was being developed by Union Carbide Metals Company, Division of Union Carbide Corp., the recent tests were of longer duration. They were conducted at Argonne National Laboratory, operated by the University of Chicago for the Atomic Energy Commission, and at Columbia-Southern Chemical Corp., Barberton, Ohio.

At Argonne, samples of commercial titanium and titanium-0.2% palladium alloy were suspended in boiling 5 percent sulfuric acid. The commercial titanium was removed after 85 hours because of excessive corrosion, but tests on titanium-palladium continued for 170 days and showed a very low corrosion rate. In addition, the corrosion rate did not increase with time. The alloy has proved to be virtually free from corrosion for as long as the scientists have been willing to run the tests.

In the tests under operating conditions at Columbia-Southern, specimens of both metals were placed in a stream of boiling, non-aerated 73 percent calcium chloride for 84 days. Titanium-0.2% palladium samples were unaffected, while the unalloyed titanium was badly pitted and perforated.



➤ SPECIMENS *are shown after being tested in 73% boiling calcium chloride solution. The right hand specimen is of unalloyed titanium while the left hand is of titanium-0.2% palladium alloy.*

Beryllium: Space–Age Metal

➤ First they found it and didn't want it. Then they wanted it and couldn't find it. Now they've found a way to find it — and a big search is beginning.

That's the mixed-up history of beryllium, an essential metal used in space vehicles, missiles, atomic reactors, automatic computers and X-ray tubes.

Discovered 132 years ago, beryllium remained a laboratory curiosity for almost a century before science found it useful as an alloy for copper in electrical switches.

Then came the nuclear and space age. Suddenly there wasn't enough beryllium to go around (current price is $71.50 a pound).

But it was tough to locate and identify beryllium, which never occurs in a pure state. It's hidden in minerals that make it difficult, at best, to identify with the naked eye.

Berylometer

Now there's a practical instrument, made in Canada, for beryllium prospecting. Its introduction makes it possible for the first time to do a practical and intelligent job of prospecting for the mineral, and a number of leading companies in the mineral field are already setting up exploration plans.

One company, International Minerals & Chemical Corporation, is already prospecting in the field with one of the first 20 instruments sold throughout the world. Called a berylometer, the instrument is built around a unique characteristic of beryllium.

"The berylometer works like a geiger counter in reverse," says Dr. F. C. Kruger, IMC's director of mining and exploration.

"A radio-active source — Antimony 124 — bombards a sample. If beryllium is present, the mineral throws back neutrons.

"The berylometer counts the neutrons, which are thrown back in direct proportion to the amount of beryllium in the sample."

Right now International's exploration crew is hunting for beryllium in Chicago libraries — libraries of mineral samples.

They're examining mineral collections at Northwestern University, the University of Chicago, and the Museum of Natural History. The crew, headed by veteran uranium geologist Dr. Jack Silman, has already surveyed IMC's library of samples from all over the world at the company's research station at Mulberry, Florida, where the lead-shielded berylometer was mounted in a station wagon for field prospecting.

The crew also prospected in North Carolina.

Next stop is the company's property in South Dakota, where beryllium is known to be located. The question here, Dr. Silman says, is whether there's enough to be economically mined, milled and processed.

Where the hunt will lead the crew and their special station wagon after that, no one is saying.

It's unlikely that beryllium hunting will become a weekend sport like uranium prospecting was, says Dr.

Kruger. It's a much more complicated job. First, the prospector has to be licensed to handle radio-active material. Furthermore the berylometer costs about $2,500, considerably more expensive than a geiger counter ($30 to $1,000), and must be transported in a lead vault in a car. The berylometer does not lend itself to inexpert or casual handling. During prospecting the berylometer is secured in the middle of a 10 foot litter carried by the two operators so they aren't exposed to the radioactivity at close range for extended periods.

Finally the berylometer won't allow the prospectors to find beryllium ore hidden far beneath the surface, Dr. Kruger adds. The prospectors must be able to spot likely looking formations because the berylometer won't penetrate more than a few inches of covering material.

"Wonder Metal"

While beryllium is hard to find, some rare and desirable characteristics promise to make the searching worthwhile. It's lighter than aluminum, has a melting point of 2,243° F (more than twice that of magnesium), is stiffer than any other material, absorbs a high degree of heat without losing its strength, and is harder than steel.

Present plans call for a heat shield of beryllium to be used in the space capsule of the Mercury Project satellite system. The capsule is designed to carry a man into space and back. Beryllium will protect the astronaut against the extreme changes in temperature.

Weight is an important factor in flight. And beryllium is less than half the weight of titanium, 70 per cent of the weight of aluminum.

A missile guidance system using beryllium to cut weight was pioneered by an Eastern college professor a few years ago. Now missile guidance systems have hundreds of beryllium gear trains, housings and other finely machined parts.

Strong Alloys

North American Aviation has been granted a patent for an aluminum alloy containing beryllium that can be cast to the higher strengths necessary for advanced missile and aircraft components. This new alloy is used for most of the aluminum castings in liquid rocket engines.

Beryllium is used extensively to harden other metals. Nickel, with the addition of 1.8 per cent of beryllium, can be heat-treated to a tensile strength as high as 260,000 pounds per square inch.

Automotive pistons, high-pressure valves, hoist bodies, jack hammer cylinders, high-speed impellers, spark plugs, electrical porcelain and compressor bodies are also being economically produced in this material.

It is used in atomic reactors to reflect neutrons.

Computer memory disks are being made of beryllium. Because of its rigidity these disks don't warp out of shape as they spin at 10,000 r.p.m. And it doesn't take much energy to start or stop these disks because of the lightness of the wonder metal.

Beryllium people think that aviation's heat barrier can be rolled back by using beryllium for aircraft control surfaces and the leading edges of wings. Air friction at several times the

speed of sound becomes high enough to melt metal.

Beryllium has a melting point six times higher than old magnesium and aluminum alloys, which melted at 300° to 400° F. and the wonder metal gives the same rigidity as stainless steel at one-sixth the weight.

Still Expensive

But cost is still a big factor. Using beryllium for the honeycomb (structural re-enforcing) material in the proposed B-70 bomber would save 20,000 pounds in weight, compared with stainless steel structural re-enforcing.

This would mean greater range and speed, but it would also cost $1,000 per square foot as compared to $250 to $300 for stainless steel.

Beryllium consumption in the U. S. was about 800,000 pounds last year. World production in the last three years has averaged about 1 million pounds annually.

Only 350 tons of ore — representing about 35,000 pounds of beryllium — was produced domestically last year. Most of this ore came from South Dakota and Colorado, although beryllium is found in small quantities in 12 states.

Domestic price of the ore is $500 a ton when sold for incentive prices to General Services Administration, which stockpiles the ore.

This premium price program to stimulate domestic exploration expires in 1962 or when 4,500 tons are purchased.

However, this incentive program has not been enough to stir much interest because, in part, many of the beryllium ores had been so hard to find before the invention of the beryllometer.

Another discouraging feature is that all beryllium ore has to be hand-sorted.

Most Imported

To meet its needs, the U. S. imports beryllium ore from 12 countries. The majority comes from Brazil, Argentina and Mozambique. Because of the cheap labor available for hand-sorting, beryllium ore costs about $300 a ton at foreign ports.

In addition to production problems, there are some others, too. Although Massachusetts Institute of Technology has solved some of the fabrication problems, there are some left. The Air Force is sponsoring research in this field.

And, too, no one has fully explored all the properties of beryllium, its alloys and compounds to determine exactly what it can do and what it cannot.

Even if all these problems are solved, no one expects beryllium to replace aluminum, copper or magnesium.

But beryllium has firmly established itself as the wonder metal of the space age.

The outlook is for increased demand, according to the Department of Interior's Bureau of Mines, as the conquest of space by the free world becomes increasingly important to man's survival.

Survival and economics have triggered the big beryllium hunt.

Book Condensations

AMINO ACIDS, PROTEINS AND CANCER BIOCHEMISTRY — John T. Edsal, Ed., preface by Sidney W. Fox and Julius Schultz — *Academic,* 244 p., illus., $7. Papers presented at the Jesse P. Greenstein Memorial Symposium, with biographical article and bibliography.

CHEMICAL INSTRUMENTATION: A Systematic Approach to Instrumental Analysis — Howard A. Strobel — *Addison-Wesley,* 653 p., illus., $9.75. Text for course in instrumental analysis on the advanced undergraduate-graduate level.

ADVANCES IN FLUORINE CHEMISTRY, Vol. I — M. Stacey, J. C. Tatlow and A. G. Sharpe, Eds. — *Academic,* 203 p., illus., $8. Reports on research done with halogen fluorides, transition metal fluorides, fluoroboric acids and high-valency metallic fluorides.

QUANTITATIVE PAPER CHROMATOGRAPHY OF STEROIDS — D. Abelson and R. V. Brooks, Eds. — *Cambridge Univ. Press,* 103 p., illus., $6. Memoir No. 8 of the Society for Endocrinology, proceedings of conference held in London in 1958.

BORATE GLASSES — L. Ya. Mazalev, transl. from Russian — *Consultants Bureau,* 159 p., illus., $10. Based on the results of investigating silicate and borate glasses, discusses thermochemical processes in glass formation, crystalloptics and physiochemical properties.

PRINCIPLES OF OPTICAL CRYSTALLOGRAPHY — A. V. Shubnikov, transl. from Russian — *Consultants Bureau,* 186 p., illus., $9.60. Parallels the course on optical crystallography given at Moscow State University.

ELEMENTS OF GENERAL CHEMISTRY — Jay A. Young — *Prentice-Hall,* 466 p., illus., $6.95. One-semester elementary and practical introduction to chemistry, serving both as foundation or terminal course.

STYLE GUIDE FOR CHEMISTS — Louis F. and Mary Fieser — *Reinhold,* 116 p., $2.95. Principles of usage, written by chemists for chemists.

INTRODUCTION TO ORGANIC CHEMISTRY — F. E. Condon and Herbert Meislich — *Holt, Rinehart & Winston,* 841 p., $10.50. Text for two-semester course, introduces concepts gradually and logically within a framework of experimental fact.

NUCLEAR SPECTROSCOPY, Part A and Part B — Fay Ajzenberg-Selove, Ed. — *Academic,* 621 p. and 526 p., illus., $16 each. Volume 9a and 9b of Pure and Applied Physics. For the use of graduate students preparing for experimental research in nuclear spectroscopy and for specialists who wish to acquire broader understanding of the field.

MODERN ASPECTS OF INORGANIC CHEMISTRY — H. J. Emeleus and J. S. Anderson — *Van Nostrand,* 3rd rev. ed., 611 p., illus., $7.75. Revised to include the most important developments in inorganic chemistry.

CHEMICAL PRODUCTIVITY — R. T. Sanderson — *Reinhold,* 330 p., illus., $11.75. This textbook attempts to emphasize the fundamental unity of inorganic chemistry.

THE STORY OF CHEMISTRY — Georg Lockemann — *Philosophical Lib.,* 277 p., $4.75. German chemist reviews the history of chemistry from antiquity to the twentieth century.

Chemistry Comments

Interesting facts in the chemical world.

➤ Acetylsalicylic acid, or aspirin, may be the most widely used drug in the world; the U. S. uses more than 9,000,000 pounds a year.

➤ A new jet-flame torch that burns a kerosene-oxygen mixture can shape granite by causing the crystals to split along natural cleavage lines.

➤ Honey is primarily a sugar solution or syrup consisting of about 80% to 85% sugar and 15% to 18.6% moisture.

➤ Ordinary sea winds may carry 10 to 100 pounds of salt per cubic mile of air, while storm winds carry 1,000 pounds or more.

➤ Acetylsalicylic acid, the chemical name for modern synthetic aspirin, was first used in medical practice in 1899 to treat rheumatic diseases.

➤ In 1958, scientists' median salaries ranged from over $10,000 for chemical engineers and medical scientists to $7,000 for biologists and agricultural scientists.

➤ Chromite is the principal ore for the production of ferrochromium, an alloying additive in steel and the production of pigments and chemicals.

➤ The average U. S. scientist, in 1958, was 38 years old and had an annual salary of $7,900.

➤ A new synthetic rubber with high flex and heat resistance has a physical structure which duplicates the natural rubber molecule and can be used both as an extender and a replacement for the natural product.

➤ The reactor core of the Atomic Energy Commission's experimental gas-cooled reactor at Oak Ridge, Tenn., will have 120 graphite columns, each measuring 16 inches square and 20 feet long; total weight is 379,000 pounds.

➤ DDT lost its effectiveness against houseflies about 1952 because resistant strains had survived and propagated.

➤ The problem of cattle trampling newly planted pines has largely been solved with the development of a chemical repellent, copper carbonate.

➤ Mineral reserves in the human adult amount to some 1,200 grams of calcium, 1,500 grams of phosphate, with carbonate, citrate, magnesium, sodium, fluoride and traces of other elements intermixed.

➤ Sulfhydryls (SH) are compounds that help living cells resist radioactivity; the simplest sulfhydryl is hydrogen sulfide, the gas produced by rotting eggs.

➤ Natural dyes, such as indigo, which is derived from a plant, were used before 3000 B.C.

➤ Liquid helium is a superfluid; if placed in a beaker, a film will creep up the inside, down the outside and continue to flow until the beaker is empty.

➤ The Chinese knew of coal in the 13th century, according to Marco Polo, and it is likely that they had been mining it for 1,000 years previously.

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